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CALCULATION OF THE NEUTRON AND GAMMA-RAY ENVIRONMENT IN AND AROUND THE AFRRI TRIGA REACTOR

Volume II

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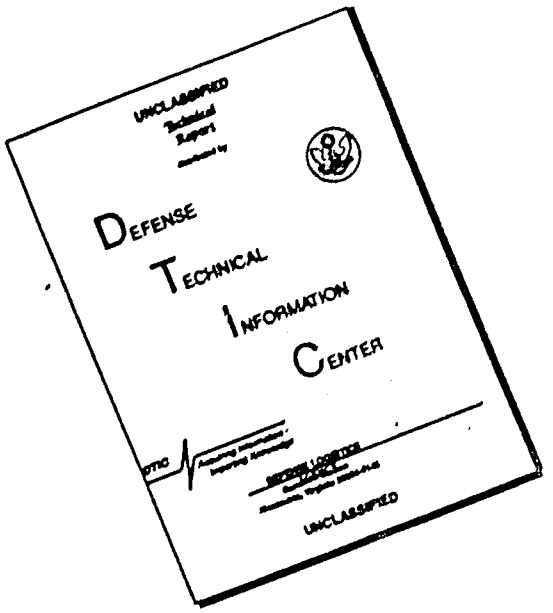

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This document summarizes the neutron spectral measurements and the neutron and gamma-ray calculations for five different irradiation geometries commonly employed in biological and electronic "radiation-damage" studies: free field in both ER1 and ER2 exposure rooms; behind a 2-inch lead wall and inside an exercise wheel; behind a 6-inch lead wall and inside a 2-inch lead cave; and at the center of a tissue-equivalent phantom located behind a 6-inch lead wall.

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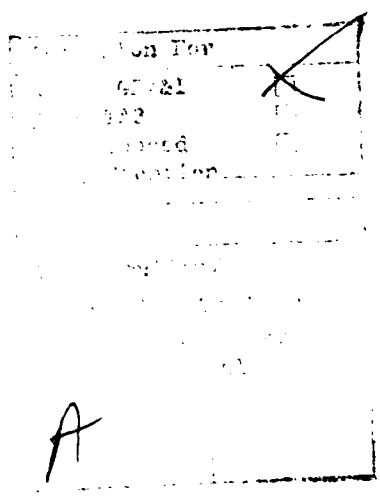
PREFACE

The author would like to thank Capt. E. Daxon and Lt. K. Ferlic of AFRRI for their support and interest in this program. The technical contributions and suggestions of Drs. T. Albert and L. Simmons of SAI are also appreciated.



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Part I

1. INTRODUCTION

The computer calculations performed for this project served two major functions. First, input spectra for the SAND II unfolding code were needed in order to unfold the foil data and produce measured spectra. These input spectra were provided as a result of some of the calculations done for this project. Good agreement on spectral shape and intensity verified the analytical techniques and the calculational effort was extended to configurations for which there were no measurements. Thus, the second major function of the calculations, to provide data for other reactor/room configurations, was accomplished using verified computational methods, assumptions, codes, and cross sections.

This data has been prepared with the AFRRI Triga user in mind. Recommended spectra, front and back angular distributions, and several commonly used responses (e.g. dose, silicon damage, etc.) are given for all of the ten configurations studied. The data is suitable for application to exposure experiments, boot-strapping to further radiation transport calculations, or input to radiation effects computer codes. All of the calculations and resulting spectra are in the DNA DLC-31[1] energy group structure consisting of 37 neutron groups and 21 gamma-ray groups. This is a commonly used group structure for radiation effects work.

The cases which have been analyzed are briefly described in Table II.1.1. The position at which the fluxes were calculated for each case is shown in Table II.1.2. As can be seen in Table II.1.1, both one-dimensional and three-dimensional calculations were done for most cases, while only one-dimensional results were calculated for others. This resulted from the fact that in many cases, the 1-D and 3-D spectra were essentially the same. Thus, there was no need to run the expensive 3-D calculations. Notable exceptions to this rule are the calculations involving the excercize wheel and the cylindrical phantom. Good examples of the agreement between the 1-D and 3-D results are the spectra calculated for the free field case in both ER1 and ER2.

This gives rise to the third large block of data (following the 1-D and 3-D results). One-dimensional neutron and gamma-ray spectra, angular data, and responses were calculated as a function of distance from the reactor center in the free field ER1 and ER2. This data, in conjunction with the data presented on the effects of different configurations on the free field spectra, should allow a

Table II.1.1. Case Descriptions.

Case	1-D	3-D	Description
1	Y	Y	ER1 free field
2	Y	Y	ER1 with 6" Pb shield
3	Y	Y	ER1 with 6" Pb shield and 2" Pb cave
4	Y	Y	ER1 with 2" Pb shield and exercise wheel
5	Y	Y	ER2 free field
6	Y	Y	ER1 free field - core moved bask 12"
7	Y	Y	ER1 with 2" Pb shield
8	Y	N	Flux at pneumatic tubes near ER2
9	Y	Y	ER1 with 6" Pb shield and cylindrical phantom
10	Y	N	ER1 free field with core moved back 5"

Table II.1.2. Detector Positions*.

Case	Location at Which Flux is Reported: Distance from Reactor Center (cm)	Height Above Floor (cm)
1	100	120
2	100	120
3	100	120
4	90	120
5	100	120**
6	100	120
7	100	120
8	In Center of Tubes	
9	100	120
10	100	120

*Same as foil positions except where noted.

**Foils were 92 cms above the floor.

reasonable estimate of the neutron and gamma-ray spectrum at any point in the rooms with a wide range of reactor and room configurations.

The next section contains a discussion of the computer codes and cross sections used for these calculations. This is followed by chapters containing the 1-D, 3-D, and flux as a function of distance results respectively.

2. COMPUTER CODES AND CROSS SECTIONS

Two radiation transport computer codes were used for this project. ANISN[2], a one-dimensional discrete ordinates code, was used for the 1-D calculations and MORSE[3], a three-dimensional Monte Carlo code was used for the 3-D calculations. In addition, the BLENDR[4] code was used to mix the cross sections external to the ANISN and MORSE codes. ANISN allows the calculation of the angular flux at each mesh boundary in a sphere, cylinder, or slab model. Due to the lamentable fact the most systems (and none of those involved in this project) are not constructed out of concentric spheres, cylinders, or planar slabs, ANISN results must be verified with higher dimensioned codes, such as MORSE. As the calculations progressed, it was learned when 1-D approximations were valid, but until that time 3-D calculations were done for all cases.

MORSE is a Monte Carlo code employing a flexible Combinatorial Geometry modeling package. It uses the same cross sections as ANISN and was, in fact, coupled to ANISN boundary leakages for this project. This coupling will be discussed in Chapter 4.

The cross section library used for all of these calculations was the DNA DLC-31 '37 neutron/21 gamma-ray group library[1]. The energy group structure can be seen in TablesII.2.2 and II.2.3. This is a convenient set to use since much of the radiation effects work has been done using this group structure. One drawback, however, is that it does not contain two elements needed for these calculations: cadmium and zirconium. This stimulated a search for other cross section libraries which did contain all of the elements needed. Unfortunately, none of the sets examined (CASK, BUGLE 80, SAILWR) filled the need. After studying the behavior of the cadmium and zirconium cross sections with energy in BNL 325[5] (the "barn book"), it was decided to substitute boron-10 with a number density 0.492 times that of cadmium for the cadmium and molybdenum at 0.10 times the number density of zirconium for the zirconium. These substitutions stem from the fact that the substitute materials have the same shape cross section with neutron energy, but a different absolute value, hence the scaling factor. In addition, note that the effects of gamma rays in these substitute materials is insignificant due to the low number density of zirconium in the fuel and the thinness of the cadmium shield region to gamma rays. For clarity, the material in the cadmium shield (really boron-10) will be referred to as cadmium. The

compositions of the various materials used in these calculations, as prepared in the mixing code BLENDR, are shown in Table II.2.1.

The proper mixture for the core material (fuel, coolant, and cladding) and 6061-T6 aluminum alloy were derived in part from information supplied by personnel at the General Atomic Company[6,7]. Another source of data necessary for preparing these mixtures (as well as other facets of this work) was the AFRRI Triga Mark-F Reactor Operations Manual[8].

Another aspect of this work involved calculating various integral flux quantities such as dose and damage for the positions of interest. This calculation consists of performing the integral:

$$\int_0^\infty F(E)R(E)dE \qquad (1)$$

where F(E) is the neutron flux per unit energy and R(E) is the response function per unit flux as a function of energy. In a many-group calculation this translates to the following sum:

$$\sum_{i=1}^{N} F_i R_i \qquad (2)$$

where F_i is the flux in the i^{th} energy group, R_i is the response for the i^{th} group, and N is the number of groups. The values of R_i for the calculated responses are shown in Table II.2.2 for the neutrons and Table II.2.2 for the gamma rays. In addition, neutron flux above 1 Mev and total neutron flux was calculated.

Other dosimetry work employing foil data and calculated spectra as input to the unfolding code[9] has shown a sensitivity to the fission spectrum used in the calculation. Accordingly, the latest ENDF/V-B compilation of the U-235 fission spectrum was used for this project[10]. It is tabulated in Table II.2.4. Only the neutron portion of the fission spectrum was used as a source for these calculations. The gamma-ray portion was omitted because the gamma-ray yield from the core is dominated by secondary gamma production. In addition, fission product gamma rays have been omitted for the same reason and because their intensity and spectrum vary with time and fuel exposure. It is felt the neither of these omissions impair the accuracy of the gamma-ray results.

Table II.2.1. Material Compositions.

Mixture	Element	Density (atoms/bn-cm)
1. Core Material	Hydrogen	5.79-2
	Molybdenum	2.26-3
	U-235	1.60-4
	U-238	6.33-4
	Oxygen	1.10-2
	Carbon	8.51-6
	Silicon	3.21-5
	Chromium	6.25-4
	Manganese	5.46-5
	Iron	2.09-3
	Nickel	3.07-4
2. Water at 1.0 gm/cc	Hydrogen	6.69-2
	Oxygen	3.35-2
3. 6061-T6 Al Alloy at 2.7 gm/cc	Silicon	3.48-4
	Copper	6.91-5
	Magnesium	6.69-4
	Chromium	6.25-5
	Aluminum	5.90-2
4. Cadmium at 8.65 gm/cc	Boron-10	2.43-2
5. Gadolimium Oxide at 7.41 gm/cc	Gadolinium	4.09-2
	Oxygen	6.13-2
6. Wood at 0.64 gm/cc	Carbon	1.43-2
	Hydrogen	2.40-2
	Oxygen	1.19-2
7. Lucite at 1.2 gm/cc	Carbon	3.61-2
	Hydrogen	5.78-2
	Oxygen	1.44-2
8. Lead at 11.35 gm/cc	Lead	3.30-2
9. Steel at 7.84 gm/cc	Iron	8.29-2
	Nickel	1.61-3
10. Permalli JN at 1.35 gm/cc	Hydrogen	4.88-2
	Boron-10	4.88-4
	Boron-11	1.77-3
	Oxygen	2.49-2
	Carbon	2.57-2
	Sodium	6.36-4
11. Air at 1 atmosphere	Nitrogen	4.03-5
	Oxygen	9.49-6
12. Phantom Tissue Solution at 1.06 gm/cc	Hydrogen	6.32-2
	Carbon	6.79-3
	Nitrogen	1.54-3
	Oxygen	2.91-2

Table II.2.2. Neutron Responses[+] as a Function of Energy.
Silicon Damage x 10 = Damage Relative to
1 MeV Fluence.

	ENERGY (MEV)	SULFUR ACTIVATION	SILICON DAMAGE[+]	NEUTRON DOSE (RAD)	NEUTRON DOSE (REM)
1	1.96E+01	1.12E-01	2.50E-01	7.86E-09	6.18E-08
2	1.69E+01	1.71E-01	2.50E-01	7.78E-09	5.47E-08
3	1.49E+01	2.25E-01	2.50E-01	7.74E-09	5.85E-08
4	1.42E+01	2.53E-01	2.50E-01	7.71E-09	5.78E-08
5	1.38E+01	2.91E-01	2.46E-01	7.49E-09	5.51E-08
6	1.28E+01	3.31E-01	2.42E-01	7.21E-09	5.16E-08
7	1.22E+01	3.76E-01	2.16E-01	6.90E-09	4.78E-08
8	1.11E+01	3.80E-01	2.29E-01	6.49E-09	4.31E-08
9	1.00E+01	3.55E-01	2.22E-01	6.23E-09	4.09E-08
10	9.05E+00	3.33E-01	2.16E-01	6.10E-09	4.09E-08
11	8.19E+00	3.23E-01	2.05E-01	5.97E-09	4.09E-08
12	7.41E+00	3.16E-01	1.82E-01	5.82E-09	4.11E-08
13	6.38E+00	2.73E-01	1.71E-01	5.57E-09	4.25E-08
14	4.97E+00	2.37E-01	2.07E-01	5.34E-09	4.16E-08
15	4.72E+00	3.00E-01	1.67E-01	6.09E-09	4.16E-08
16	4.07E+00	1.90E-01	1.33E-01	4.56E-09	3.87E-08
17	3.01E+00	9.10E-02	1.40E-01	4.00E-09	3.56E-08
18	2.39E+00	8.96E-02	1.50E-01	3.82E-09	3.49E-08
19	2.31E+00	3.62E-02	1.38E-01	3.74E-09	3.49E-08
20	1.83E+00	1.03E-03	9.61E-02	3.52E-09	3.69E-08
21	1.11E+00	4.10E-06	9.95E-02	2.94E-09	3.23E-08
22	5.50E-01	0.00E+00	7.11E-02	1.69E-09	1.68E-08
23	1.58E-01	0.00E+00	7.01E-03	9.72E-10	7.81E-09
24	1.11E-01	0.00E+00	8.85E-03	7.45E-10	4.97E-09
25	5.25E-02	0.00E+00	7.60E-03	5.88E-10	2.75E-09
26	2.48E-02	0.00E+00	7.50E-03	6.13E-10	1.92E-09
27	2.19E-02	0.00E+00	7.50E-03	4.49E-10	1.38E-09
28	1.03E-02	0.00E+00	7.50E-03	4.21E-10	1.00E-09
29	3.35E-03	0.00E+00	7.50E-03	4.79E-10	1.03E-09
30	1.23E-03	0.00E+00	7.50E-03	5.25E-10	1.05E-09
31	5.83E-04	0.00E+00	7.50E-03	5.68E-10	1.12E-09
32	1.01E-04	0.00E+00	7.50E-03	6.94E-10	1.17E-09
33	2.90E-05	0.00E+00	7.50E-03	6.18E-10	1.24E-09
34	1.07E-05	0.00E+00	7.50E-03	6.28E-10	1.26E-09
35	3.06E-06	0.00E+00	7.50E-03	6.22E-10	1.25E-09
36	1.13E-06	0.00E+00	7.50E-03	6.70E-10	1.20E-09
37	4.14E-07	0.00E+00	7.50E-03	6.17E-10	1.03E-09

Table II.2.3. Gamma Dose as a Function of Energy.

	ENERGY (MEV)	GAMMA DOSE
1	1.40E+01	3.21E-09
2	1.00E+01	2.47E-09
3	8.00E+00	2.09E-09
4	7.00E+00	1.87E-09
5	6.00E+00	1.66E-09
6	5.00E+00	1.44E-09
7	4.00E+00	1.10E-09
8	3.00E+00	1.01E-09
9	2.50E+00	8.71E-10
10	2.00E+00	7.26E-10
11	1.50E+00	5.64E-10
12	1.00E+00	4.11E-10
13	7.00E-01	2.93E-10
14	4.50E-01	1.92E-10
15	3.00E-01	1.11E-10
16	1.50E-01	6.48E-11
17	1.00E-01	3.71E-11
18	7.00E-02	3.67E-11
19	4.50E-02	6.33E-11
20	3.00E-02	1.42E-10
21	2.00E-02	4.41E-10

Table II.2.4. ENDF/V-B U-235 Fission Spectrum Collapsed to the DLC-31 Group Structure.

Group	Energy (MeV)	S(E)ΔE	Group	Energy (MeV)	S(E)ΔE
1	19.6	3.81-6	21	1.11	1.92-1
2	16.9	1.94-5	22	0.55	1.20-1
3	14.9	1.98-5	23	0.158	1.03-2
4	14.2	1.46-5	24	0.111	1.04-2
5	13.8	8.61-5	25	5.25-2	3.48-3
6	12.8	7.53-5	26	2.48-2	2.89-4
7	12.2	3.39-4	27	2.19-2	9.33-4
8	11.1	7.28-4	28	1.03-2	3.92-4
9	10.0	1.42-3	29	3.35-3	6.62-5
10	9.05	2.56-3	30	1.23-3	1.29-5
11	8.19	4.27-3	31	5.83-4	5.74-6
12	7.41	1.11-2	32	1.01-4	3.79-7
13	6.38	3.68-2	33	2.90-5	5.35-8
14	4.97	1.07-2	34	1.07-5	1.30-8
15	4.72	3.95-2	35	3.06-6	1.85-9
16	4.07	1.09-1	36	1.13-6	4.22-10
17	3.01	1.05-1	37	4.14-7	1.40-10
18	2.39	1.58-2			
19	2.31	1.11-1			
20	1.83	2.14-1			

3. ONE-DIMENSIONAL CALCULATIONS

3.1. One-Dimensional Models

ANISN calculations are limited to systems of concentric spheres, cylinders, and planar slabs. Clearly, a slab model for the cylindrical core and tank of the AFRRI Triga reactor is inappropriate. Because the core is a right cylinder, a cylindrical model might seem to be the most correct approach. However, the core has a radius of 21.8 cms and a height (length) of 38.1 cms. A one-dimensional cylindrical model necessarily consists of concentric cylinders which are infinitely long. As the distance from the core to the detector is increased, the core will begin to look more and more like a sphere than an infinite cylinder. Thus, it was not clear at the outset whether a spherical or cylindrical model would be most accurate. The question was resolved by performing calculations with both models and comparing the results to measurements made by AFRRI personnel.

The AFRRI measurements which were used consisted of placing sulfur buttons on the face of the reactor tank and irradiating them for ten minutes at a reactor power of 5 kilowatts[11]. For the purposes of this application only the button which was placed at the core midplane on the part of the tank which extends the furthest into the room was used. The placement and application of the rest of the buttons will be discussed in the next chapter. Using the $^{32}S(n,p)$ reaction, the "sulfur fluence" could be measured at the position of each button. This sulfur fluence can also be taken to be the fluence of neutrons with energy greater than or equal to 3 Mev. For the button of interest here, the sulfur fluence was measured to be 7.86×10^{11} n/cm^2.

A cylindrical calculation was run which yielded a sulfur fluence of 1.08×10^{12} n/cm^2 or 37% higher than the measurement. A spherical calculation was then run in which the radius of the core was determined by requiring that the sphere which represented the core should have the same volume as the real core. This yielded a spherical core radius of 23.84 cms. The spherical calculation yielded a sulfur fluence of 8.55×10^{11} n/cm^2, only 9% higher than the measurement. This relative agreement, in conjunction with the fact that the spherical model becomes more and more appropriate as the detector position is moved away from the core, makes the choice of the spherical model clear.

Having decided on spherical geometry, the position of the wooden walls in the model was studied. This is not straightforward for these 1-D calculations because the distance from the core to the back wall is different from the distance from the core to the ceiling, floor, and side walls. In ER1 the back wall is about 20 feet from the reactor center while the floor s about 4 feet away and the ceiling is about 6 feet away (these numbers differ slightly in ER2). The question is an important one because of the angular information required from these calculations. In addition to knowing the neutron and gamma-ray spectra at a particular location, it is necessary to also know the "front" and "back" spectra. "Front" means that component of the spectrum which is directed away from the front wall where the reactor is located. In other words, it is that component of the spectrum which would impinge upon the front of an irradiation subject facing the reactor. "Back" refers to that part of the spectrum which is directed away from the back wall. It is the spectrum which would impinge upon the back of an irradiation subject facing the reactor. As might be expected, the back flux is sensitive to the position of the wall in the spherical ANISN model. In general, the total flux (sum of the front and back fluxes) is not sensitive to the wall position because the front flux is usually much larger than the back flux.

This question was resolved by comparing the back flux for the ER1 free field case calculated with 1-D and 3-D codes. Because the 3-D model has the walls, ceiling, and floor in the proper position, the wall position in the 1-D model was adjusted to agree with the 3-D spectrum. One-dimensional calculations were run with walls at 20 feet from the core center and 10 feet from the core center. The 1-D and 3-D spectra agreed best with the walls at 20 feet. When the walls are moved in to 10 feet, the magnitude of the back flux increases by a factor of about 3. It was thus shown that the walls in the 1-D model for ER1 should be 20 feet from the core center and, by extension, the walls for ER2 should be 14 feet from the core center.

With geometry and wall position questions answered, the 1-D models for the different cases could be formulated. They are shown in Tables II.3.1 through II.3.10. The position at which the spectra were reported for each case is shown in Table II.1.2.

Table II.3.1.

1-D Model

Case No.: 1
Description: ER1 free field

	Zone	Material	Outer Radius (cm)
1.	Core	Core material	23.840
2.	Coolant	Water	26.353
3.	Shroud	Al	26.829
4.	Coolant	Water	28.575
5.	Tank and Al Shield	Al	29.251
6.	Gd_2O_3	Gd_2O_3	29.254
7.	Cd Shield	Cd	29.356
8.	Air	Air	638.956
9.	Gd_2O_3 Paint	Gd_2O_3	638.957
10.	Wood	Wood	669.438

Table II.3.2.

1-D Model

Case No.: 2
Description: ER1 with 6" Pb Shield

	Zone	Material	Outer Radius (cm)
1.	Core	Core material	23.840
2.	Coolant	Water	26.353
3.	Shroud	Al	26.829
4.	Coolant	Water	28.575
5.	Tank and Al Shield	Al	29.251
6.	Gd_2O_3 Paint	Gd_2O_3	29.254
7.	Cadmium	Cd	29.356
8.	Air	Air	43.500
9.	Al Sheet	Al	44.135
10.	6" Pb Shield	Pb	59.375
11.	Al Sheet	Al	60.010
12.	Air	Air	609.600
13.	Gd_2O_3 Paint	Gd_2O_3	609.601
14.	Wood	Wood	640.080

Table II.3.3.

1-D Model

Case No.: 3

Description: ER1 with 6" Pb Shield and 2" Pb Cave

	Zone	Material	Outer Radius (cm)
1.	Core	Core material	23.840
2.	Coolant	Water	26.353
3.	Shroud	Al	26.829
4.	Coolant	Water	28.575
5.	Tank and Al Shield	Al	29.251
6.	Gd_2O_3 Paint	Gd_2O_3	29.254
7.	Cadmium	Cd	29.356
8.	Air	Air	43.500
9.	Al Sheet	Al	44.135
10.	6" Pb Shield	Pb	59.375
11.	Al Sheet	Al	60.010
12.	Front of Cave	Pb at 42.2% density	106.096
13.	Back Wall of Cave	Pb	113.208
14.	Air	Air	609.600
15.	Gd_2O_3 Paint	Gd_2O_3	609.601
16.	Wood	Wood	640.080

Table II.3.4.

1-D Model

Case No.: 4

Description: ER1 with 2" Pb Shield and Exercise Wheel

	Zone	Material	Outer Radius (cm)
1.	Core	Core material	23.840
2.	Coolant	Water	26.353
3.	Shroud	Al	26.829
4.	Coolant	Water	28.575
5.	Tank and Al Shield	Al	29.251
6.	Gd_2O_3 Paint	Gd_2O_3	29.254
7.	Cadmium	Cd	29.356
8.	Air	Air	43.500
9.	Al Sheet	Al	44.135
10.	2" Pb Shield	Pb	49.215
11.	Al Sheet	Al	49.850
12.	Air	Air	71.990
13.	Lucite Box Wall	Lucite	73.260
14.	Inside of Lucite Box	Lucite at 11% density	103.740
15.	Box Wall and Exercise Wheel Disc	Lucite	106.598
16.	Inside of Exercise Wheel	Al at 1% density	167.558
17.	Exercise Wheel Disc	Lucite	169.146
18.	Air	Air	609.600
19.	Gd_2O_3 Paint	Gd_2O_3	609.601
20.	Wood	Wood	640.082

Table II.3.5.

1-D Model

Case No.: 5
Description: ER2 Free Field

	Zone	Material	Outer Radius (cm)
1.	Core	Core material	23.840
2.	Coolant	Water	26.353
3.	Shroud	Al	26.829
4.	Coolant	Water	29.052
5.	Tank	Al	29.687
6.	Air	Air	457.200
7.	Gd_2O_3	Gd_2O_3	457.201
8.	Wood	Wood	487.680

Table II.3.6.

1-D Model

Case No.: 6

Description: ER1 Free Field - Core Moved Back 12" in Tank

	Zone	Material	Outer Radius (cm)
1.	Core	Core material	23.840
2.	Coolant	Water	26.353
3.	Shroud	Al	26.829
4.	Coolant	Water	56.769
5.	Tank and Al Shield	Al	57.445
6.	Gd_2O_3 Paint	Gd_2O_3	57.448
7.	Cadmium	Cd	57.550
8.	Air	Air	640.080
9.	Gd_2O_3 Paint	Gd_2O_3	640.081
10.	Wood	Wood	670.560

Table II.3.7.

1-D Model

Case No.: 7

Description: ER1 with 2" Pb Shield

	Zone	Material	Outer Radius (cm)
1.	Core	Core material	23.840
2.	Coolant	Water	26.353
3.	Shroud	Al	26.829
4.	Coolant	Water	28.575
5.	Tank and Al Shield	Al	29.251
6.	Gd_2O_3 Paint	Gd_2O_3	29.254
7.	Cadmium	Cd	29.356
8.	Air	Air	43.500
9.	Al Sheet	Al	44.135
10.	2" Pb Shield	Pb	49.215
11.	Al Sheet	Al	49.850
12.	Air	Air	609.600
13.	Gd_2O_3 Paint	Gd_2O_3	609.601
14.	Wood	Wood	640.080

Table II.3.8.

1-D Model

Case No.: 8

Description: Flux at Pneumatic Tubes Near ER2

	Zone	Material	Outer Radius (cm)
1.	Core	Core material	23.840
2.	Coolant	Water	26.353
3.	Shroud	Al	26.829
4.	Coolant	Water	28.575
5.	Tubes	Water at 43.8% density + [illegible] at 13.7% density	31.750
6.	Coolant	Water	62.230

Table II.3.9.

1-D Model

Case No.: 9
Description: ER1 with 6" Pb Shield and Cylindrical Phantom

	Zone	Material	Outer Radius (cm)
1.	Core	Core material	23.840
2.	Coolant	Water	26.353
3.	Shroud	Al	26.829
4.	Coolant	Water	28.575
5.	Tank and Al Shield	Al	29.251
6.	Gd_2O_3 Paint	Gd_2O_3	29.254
7.	Cadmium	Cd	29.356
8.	Air	Air	43.500
9.	Al Sheet	Al	44.135
10.	6" Pb Shield	Pb	59.375
11.	Al Sheet	Al	60.010
12.	Air	Air	91.120
13.	Phantom	Phantom Tissue Solution	108.900
14.	Air	Air	609.600
15.	Gd_2O_3 Paint	Gd_2O_3	609.601
16.	Wood	Wood	640.080

Table II.3.10.

1-D Model

Case No.: 10

Description: ER1 Free Field - Core Moved Back 5" in Tank

	Zone	Material	Outer Radius (cm)
1.	Core	Core material	23.840
2.	Coolant	Water	26.353
3.	Shroud	Al	26.829
4.	Coolant	Water	39.529
5.	Tank and Al Shield	Al	40.205
6.	Gd_2O_3 Paint	Gd_2O_3	40.208
7.	Cadmium	Cd	40.310
8.	Air	Air	640.080
9.	Gd_2O_3 Paint	Gd_2O_3	640.081
10.	Wood	Wood	670.560

3.2. One-Dimensional Results

The results of the ANISN calculations for all ten cases are displayed in Figures II.3.1 through II.3.60 and Tables II.3.11 through II.3.30. The data is presented in increasing order starting with Case 1. For each case the first figure is the front neutron spectrum, the second is front gamma spectrum, the third is back neutron spectrum, the fourth is back gamma spectrum, the fifth is total neutron spectrum, and the sixth is total gamma spectrum. These six figures are followed two tables (one for neutrons, the other for gamma rays) containing the tabulated spectra data. The spectra are given in units of particles/cm^2/sec/unit lethargy/kilowatt reactor power. The lethargy width of an energy group with upper and lower bounds of E_u and E_l respectively is:

$$\Delta u = \ln(E_u/E_l). \qquad (3)$$

Thus, to get the flux in units of particles/cm^2/sec for a particular energy group, the numbers given here should be multiplied by the lethargy width of the group and the reactor power in kilowatts. This system of units was chosen to facilitate comparison of these spectra with other published data for various irradiation fields.

In addition to the spectra, certain commonly use integral quantities were calculated for each case. These responses are also broken down into front, back, and total components and are shown in Table II.3.31 through II.3.33.

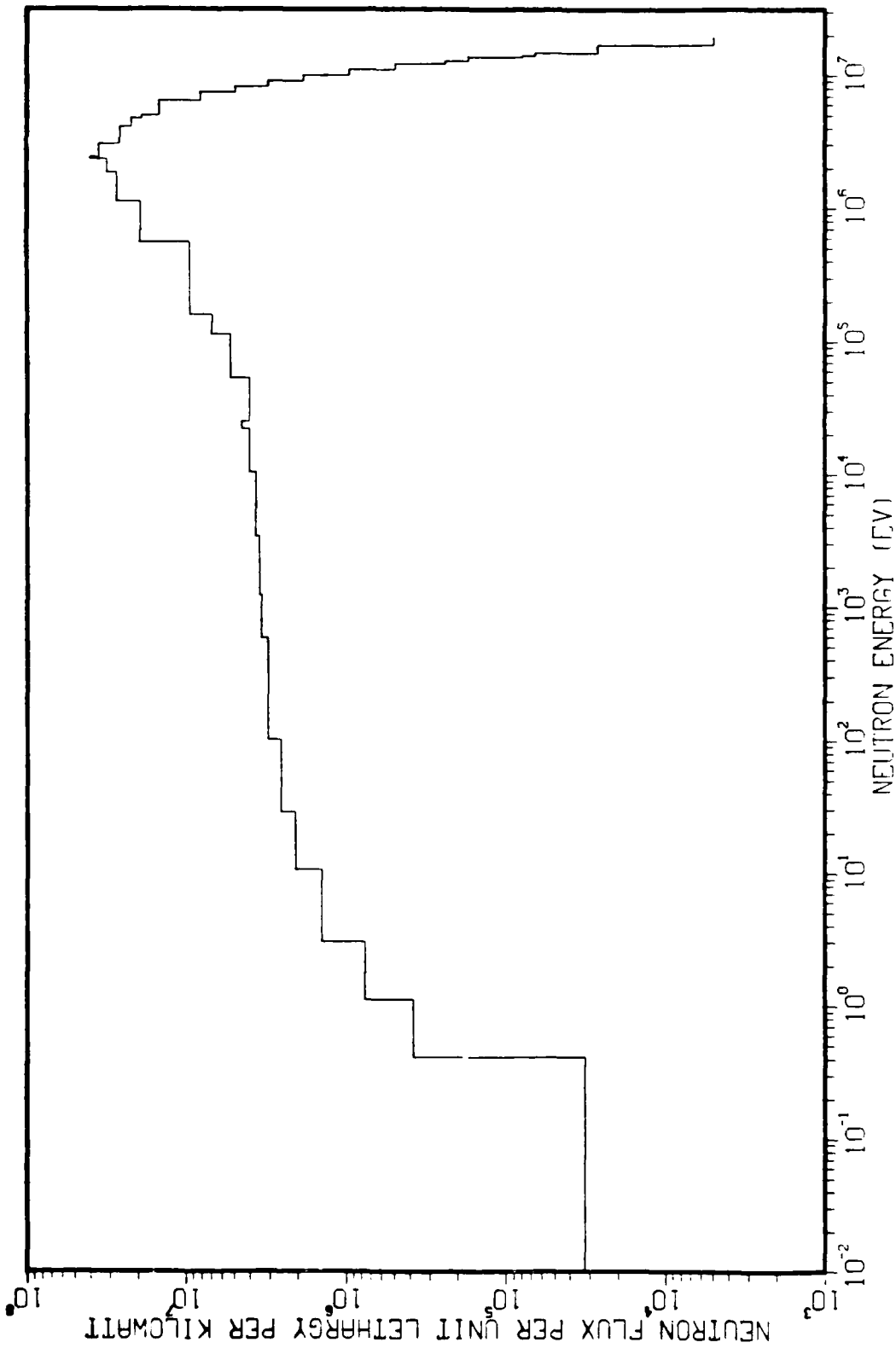

Figure II.3.1. Front (1-D) Neutron Flux vs Energy ER1 Free Field.

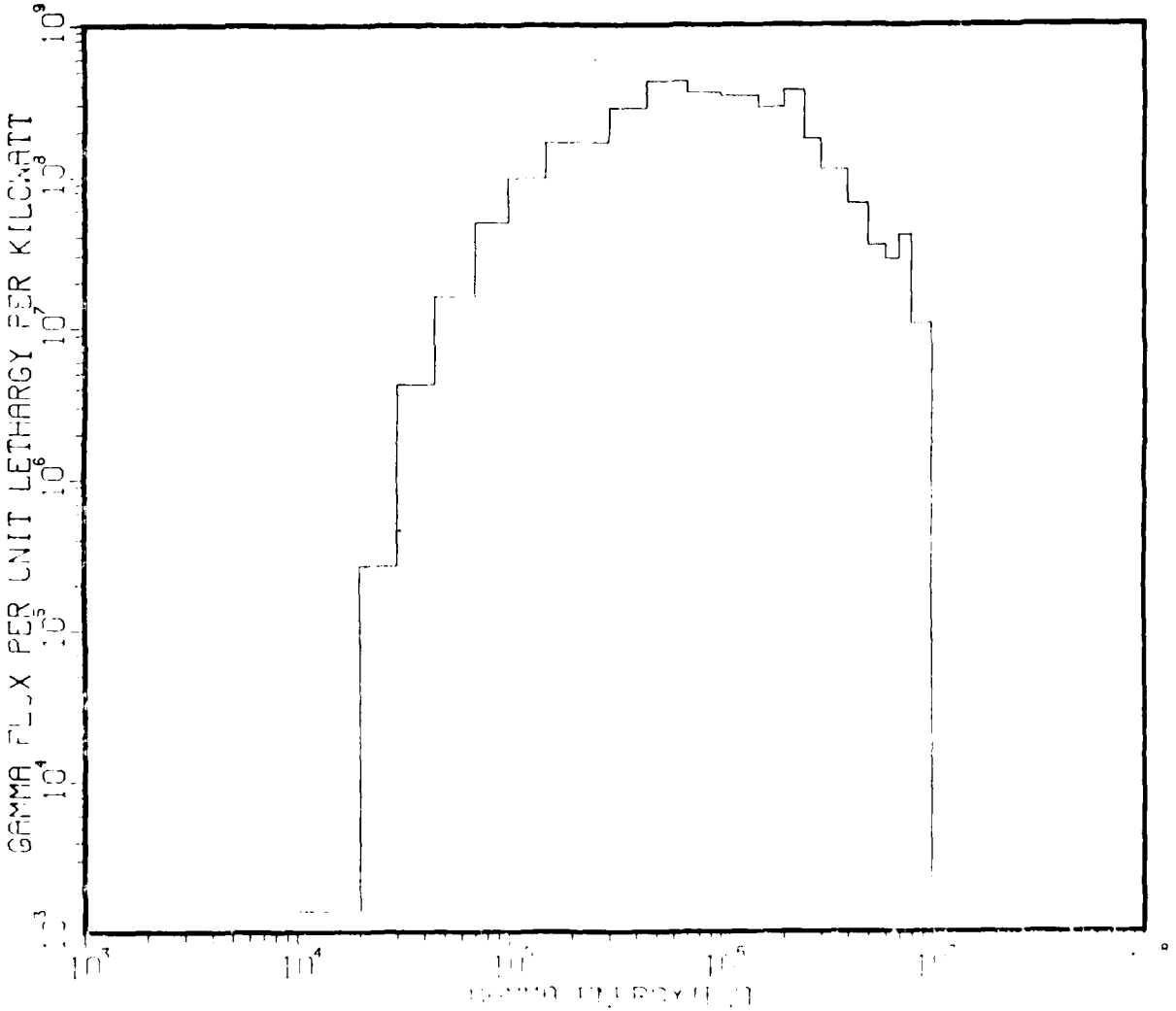

Figure II.3.2. Front Gamma Flux vs Energy ER1 Free Field.

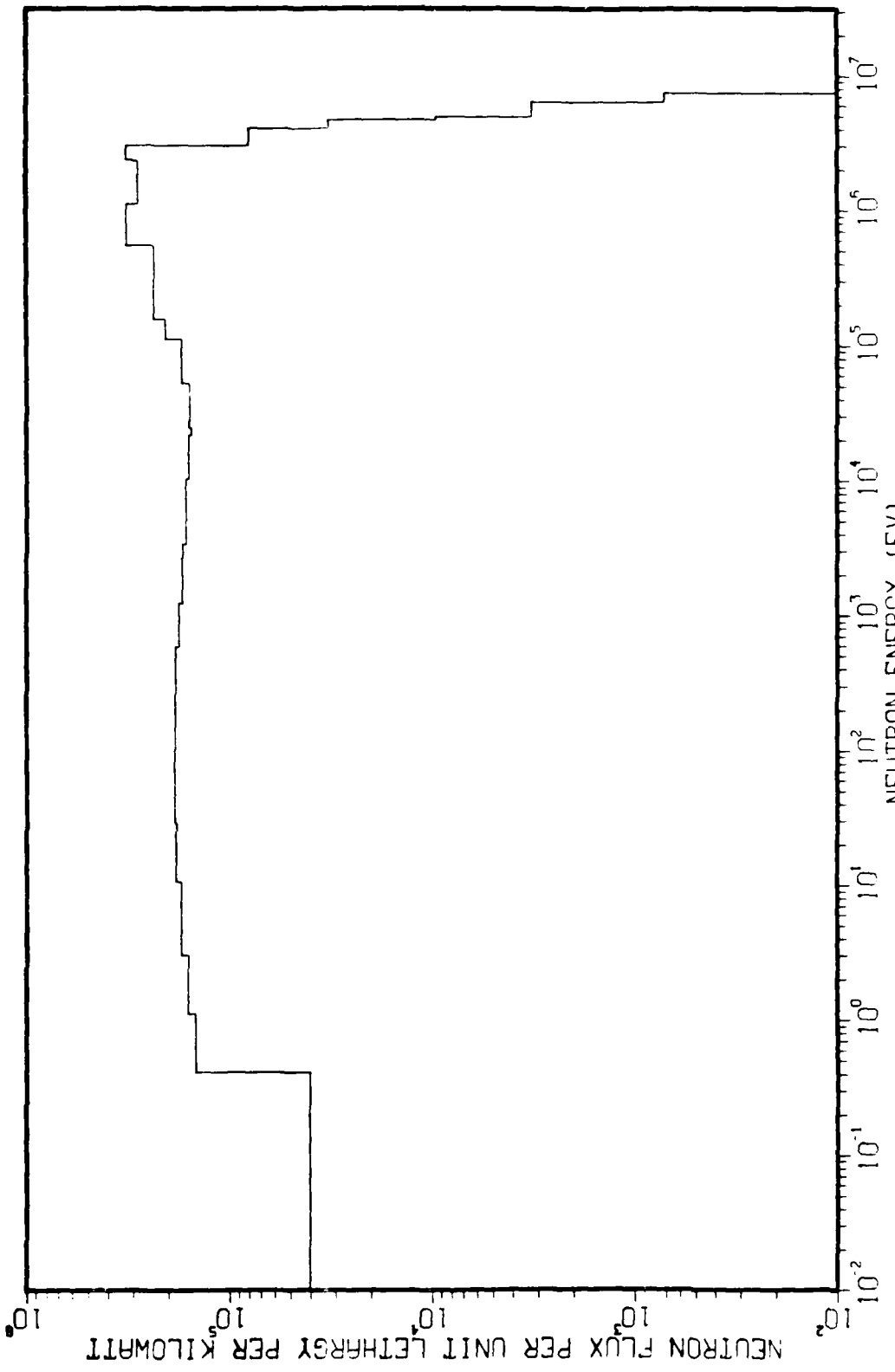

Figure II.3.3. Back (1-D) Neutron Flux vs Energy ER1 Free Field.

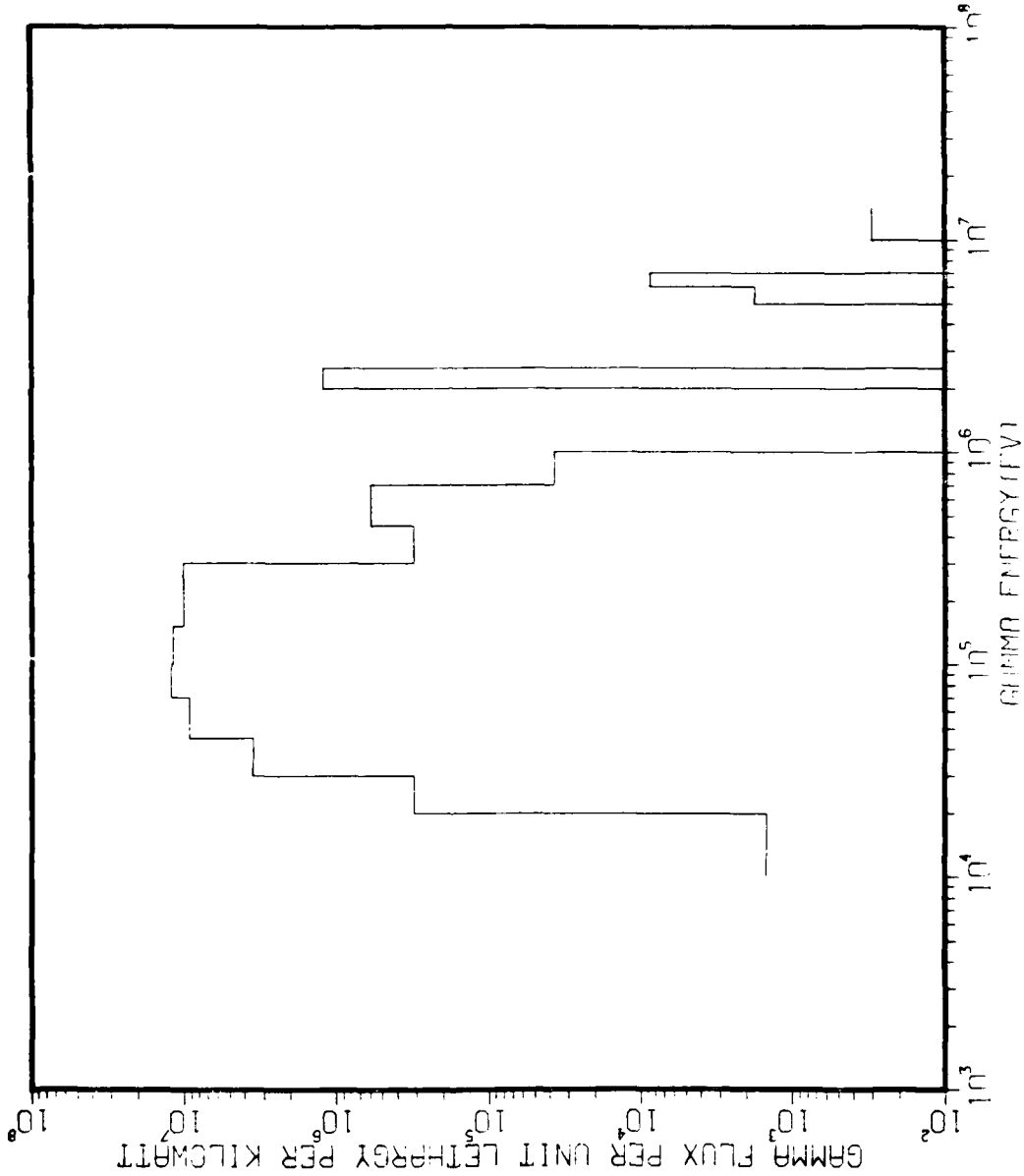

Figure II.3.4. Back Gamma Flux vs Energy ER1 Free Field.

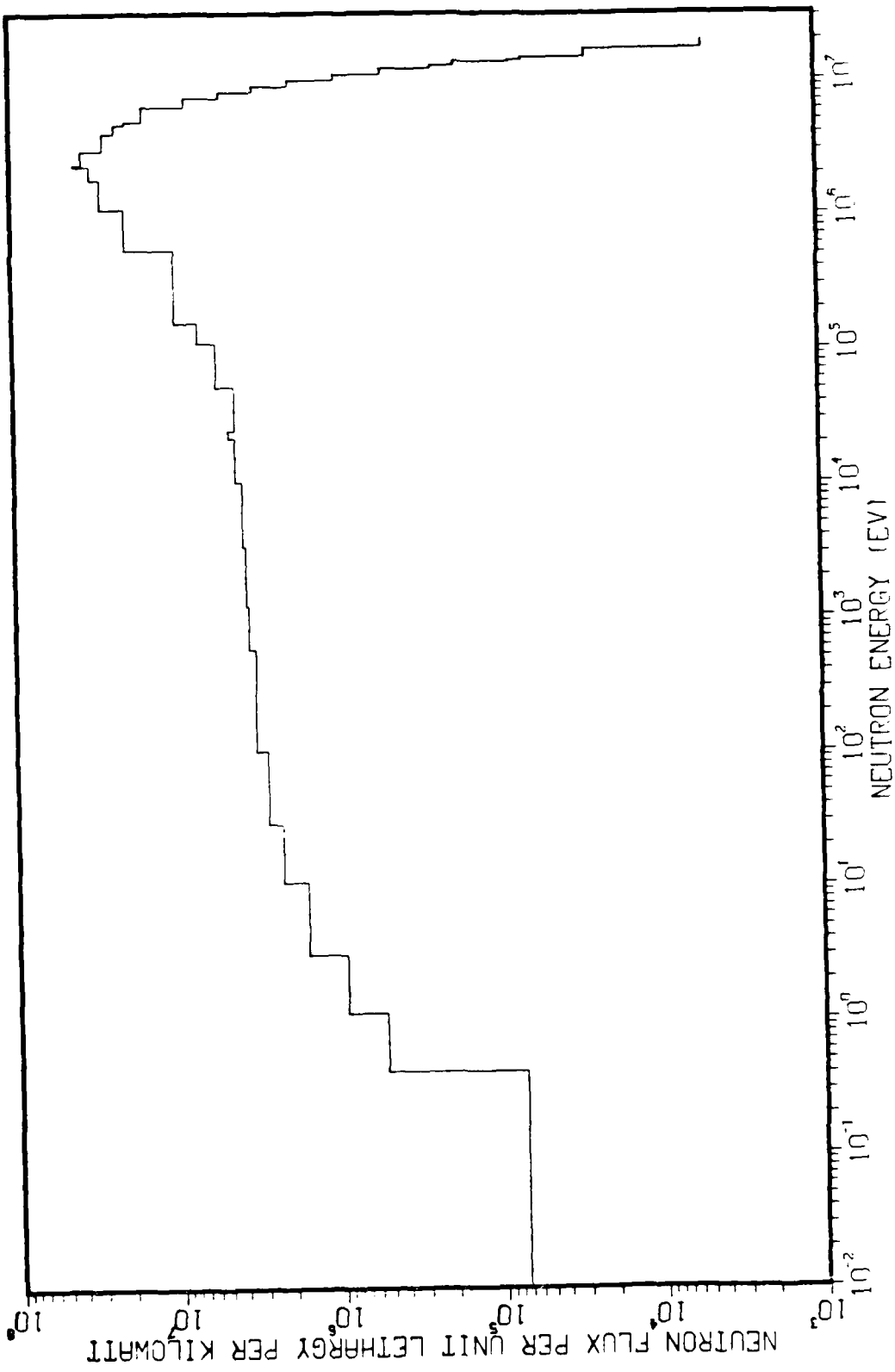

Figure 11.3.5. Total (Front+Back, 1-D) Neutron Flux vs Energy ER1 Free Field.

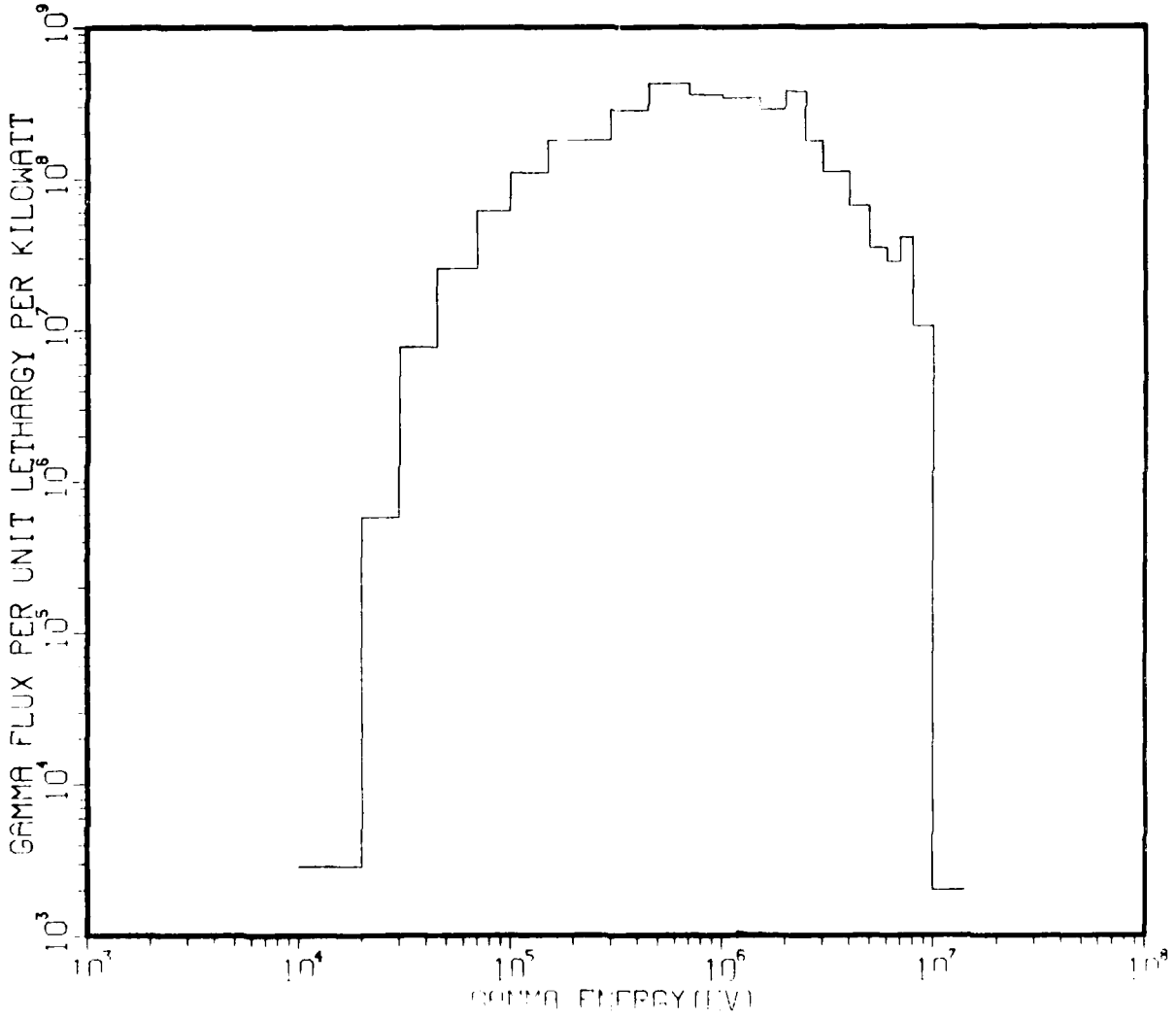

Figure II.3.6. Total (Front+Back) Gamma Flux vs Energy ER1 Free Field.

Table II.3.11. Neutron Flux per Unit Lethargy per Kilowatt.

ER1 FREE FIELD

GROUP	ENERGY (EV)	FRONT	BACK	TOTAL
1	1.960E+07	4.97E+03	0.00E+00	4.97E+03
2	1.690E+07	2.66E+04	0.00E+00	2.66E+04
3	1.490E+07	6.56E+04	0.00E+00	6.56E+04
4	1.420E+07	7.91E+04	0.00E+00	7.91E+04
5	1.380E+07	1.74E+05	0.00E+00	1.74E+05
6	1.280E+07	2.41E+05	0.00E+00	2.41E+05
7	1.220E+07	4.93E+05	0.00E+00	4.93E+05
8	1.110E+07	9.53E+05	0.00E+00	9.53E+05
9	1.000E+07	1.86E+06	0.00E+00	1.86E+06
10	9.050E+06	3.07E+06	0.00E+00	3.07E+06
11	8.190E+06	4.91E+06	0.00E+00	4.91E+06
12	7.410E+06	8.13E+06	7.06E+02	8.13E+06
13	6.380E+06	1.48E+07	3.20E+03	1.48E+07
14	4.970E+06	1.89E+07	9.47E+03	1.89E+07
15	4.720E+06	2.22E+07	3.23E+04	2.22E+07
16	4.070E+06	2.61E+07	8.05E+04	2.62E+07
17	3.010E+06	3.52E+07	3.21E+05	3.56E+07
18	2.390E+06	3.97E+07	2.98E+05	4.00E+07
19	2.310E+06	3.15E+07	2.83E+05	3.18E+07
20	1.830E+06	2.71E+07	2.82E+05	2.74E+07
21	1.110E+06	1.93E+07	3.23E+05	1.96E+07
22	5.500E+05	9.52E+06	2.35E+05	9.75E+06
23	1.580E+05	6.87E+06	2.06E+05	7.08E+06
24	1.110E+05	5.27E+06	1.72E+05	5.44E+06
25	5.250E+04	4.05E+06	1.57E+05	4.21E+06
26	2.480E+04	4.48E+06	1.54E+05	4.63E+06
27	2.190E+04	4.05E+06	1.58E+05	4.20E+06
28	1.030E+04	3.69E+06	1.64E+05	3.85E+06
29	3.350E+03	3.50E+06	1.71E+05	3.67E+06
30	1.230E+03	3.38E+06	1.79E+05	3.56E+06
31	5.830E+02	3.09E+06	1.85E+05	3.27E+06
32	1.010E+02	2.58E+06	1.87E+05	2.77E+06
33	2.900E+01	2.09E+06	1.85E+05	2.27E+06
34	1.070E+01	1.44E+06	1.74E+05	1.61E+06
35	3.060E+00	7.69E+05	1.60E+05	9.29E+05
36	1.130E+00	3.82E+05	1.48E+05	5.30E+05
37	4.140E-01	3.24E+04	4.05E+04	7.29E+04

Table II.3.12. Gamma Flux per Unit Lethargy per Kilowatt.

GROUP	ENERGY (EV)	ERI FREE FIELD FRONT	BACK	TOTAL
1	1.400E+07	1.68E+03	3.01E+02	1.98E+03
2	1.000E+07	1.05E+07	0.00E+00	1.05E+07
3	8.000E+06	4.07E+07	0.00E+00	4.07E+07
4	7.000E+06	2.81E+07	8.57E+03	2.81E+07
5	6.000E+06	3.48E+07	1.75E+03	3.48E+07
6	5.000E+06	6.61E+07	0.00E+00	6.61E+07
7	4.000E+06	1.11E+08	0.00E+00	1.11E+08
8	3.000E+06	1.77E+08	0.00E+00	1.77E+08
9	2.500E+06	3.73E+08	1.22E+06	3.74E+08
10	2.000E+06	2.85E+03	0.00E+00	2.85E+08
11	1.500E+06	3.41E+08	0.00E+00	3.41E+08
12	1.000E+06	3.58E+08	3.67E+04	3.58E+08
13	7.000E+05	4.24E+08	5.95E+05	4.25E+08
14	4.500E+05	2.84E+08	3.12E+05	2.84E+08
15	3.000E+05	1.69E+08	1.02E+07	1.79E+08
16	1.500E+05	9.78E+07	1.19E+07	1.10E+08
17	1.000E+05	4.93E+07	1.21E+07	6.14E+07
18	7.000E+04	1.60E+07	9.24E+06	2.52E+07
19	4.500E+04	4.22E+06	3.54E+06	7.76E+06
20	3.000E+04	2.68E+05	3.12E+05	5.79E+05
21	2.000E+04	1.38E+03	1.49E+03	2.87E+03

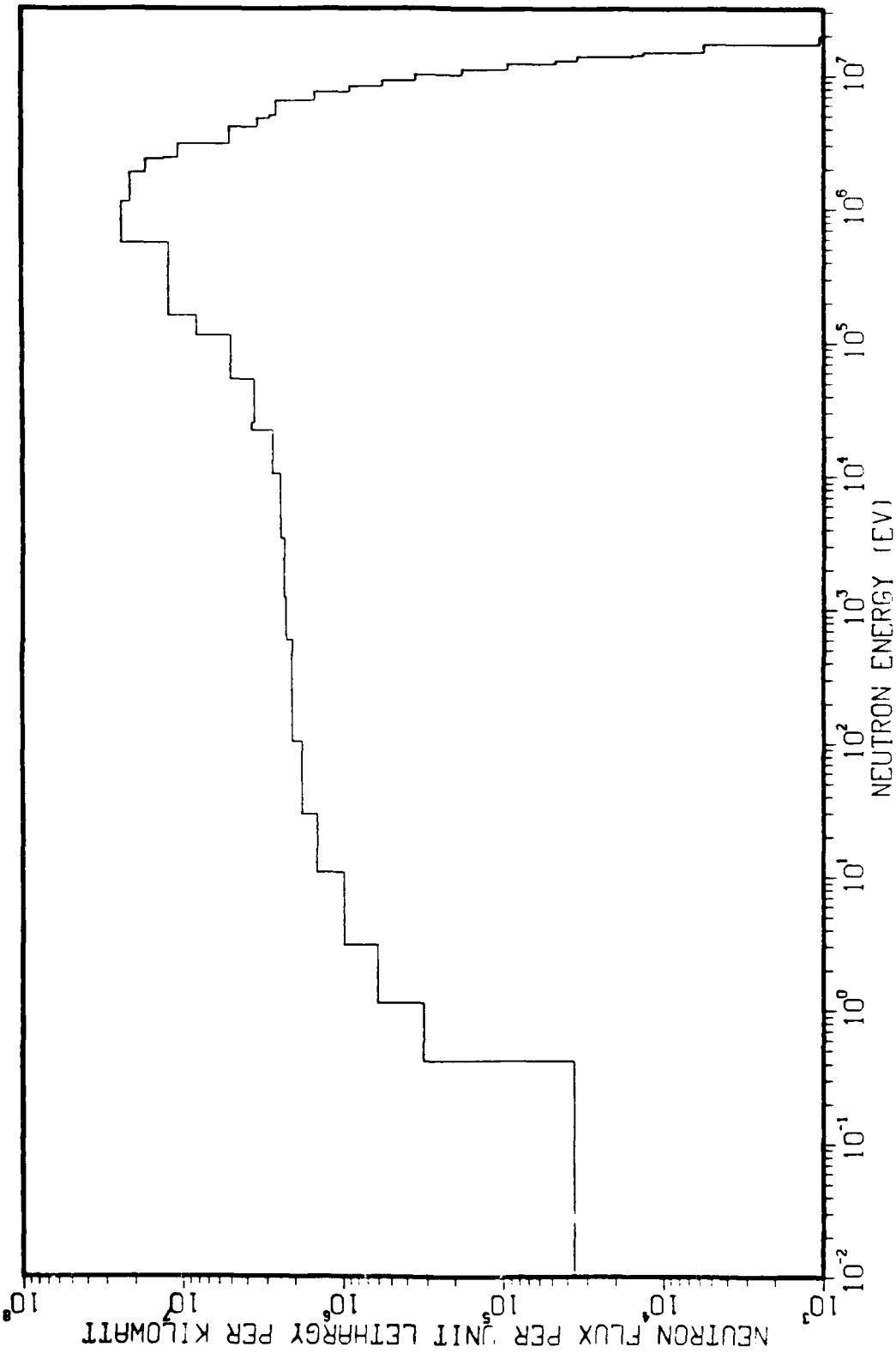

Figure II.3.7. Front (1-D) Neutron Flux vs Energy ER1 with 6" Pb.

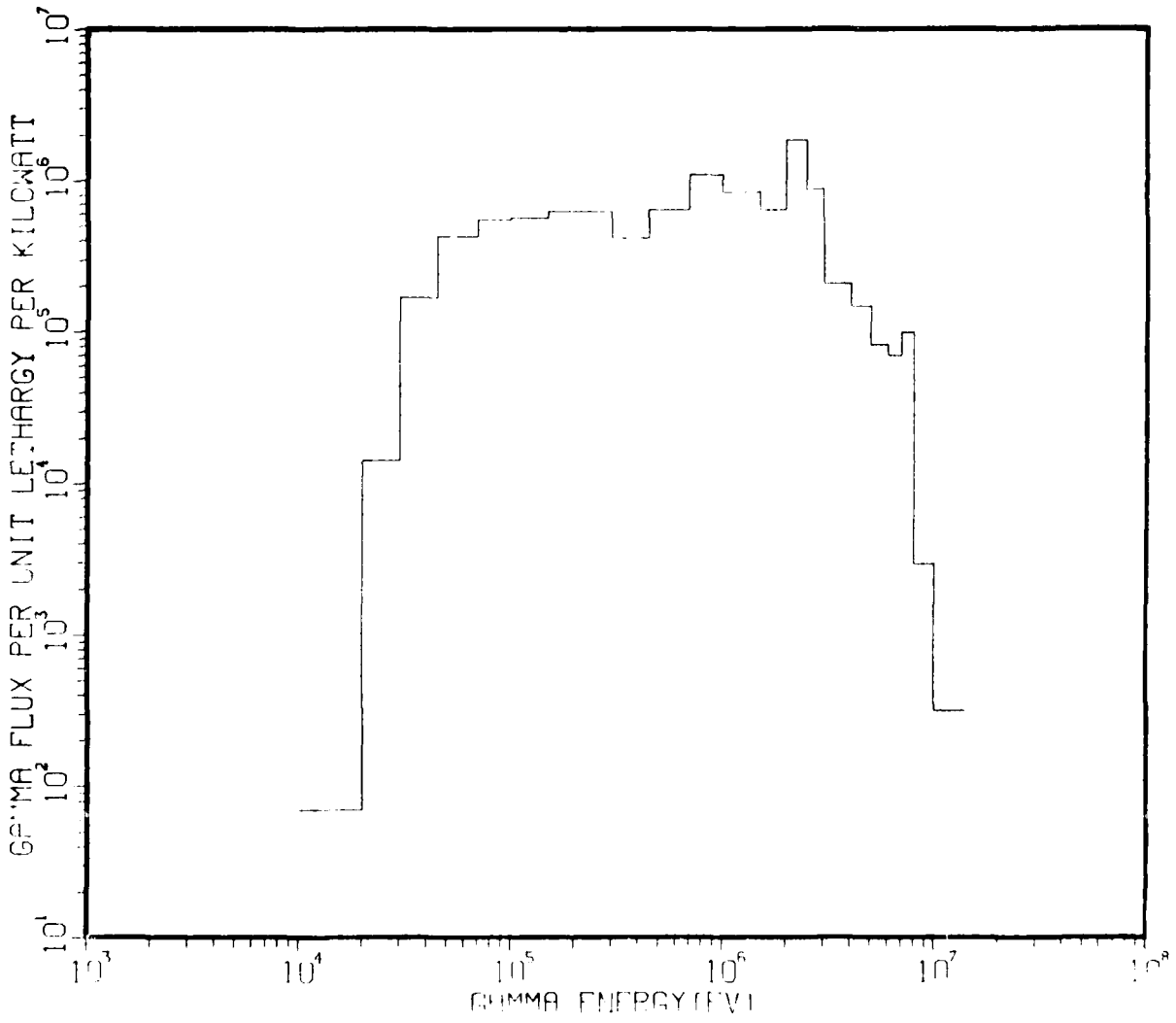

Figure II.3.8. Front Gamma Flux vs Energy ER1 With 6" PB.

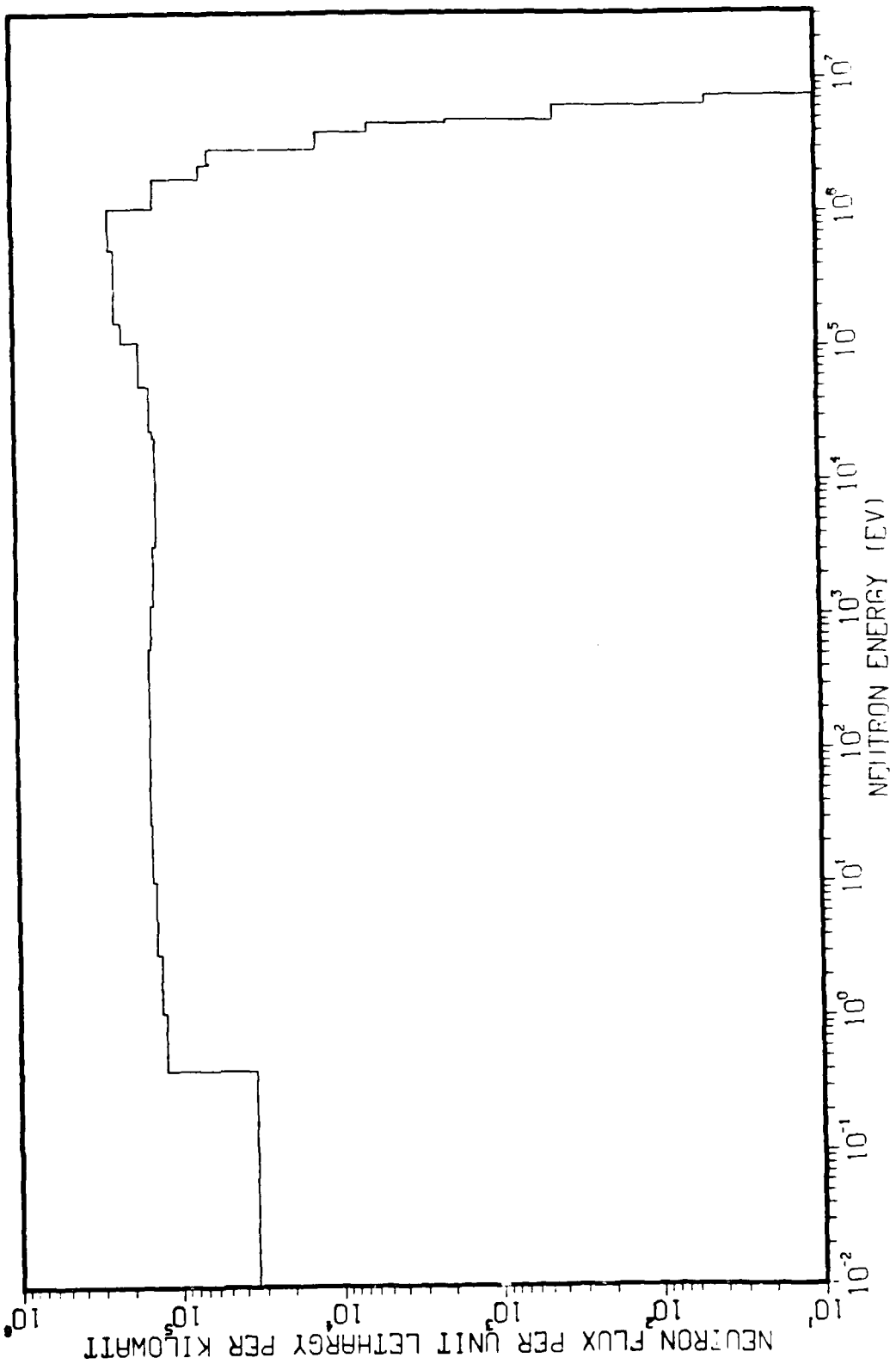

Figure II.3.9. Back (1-D) Neutron Flux vs Energy ER1 With 6" PB.

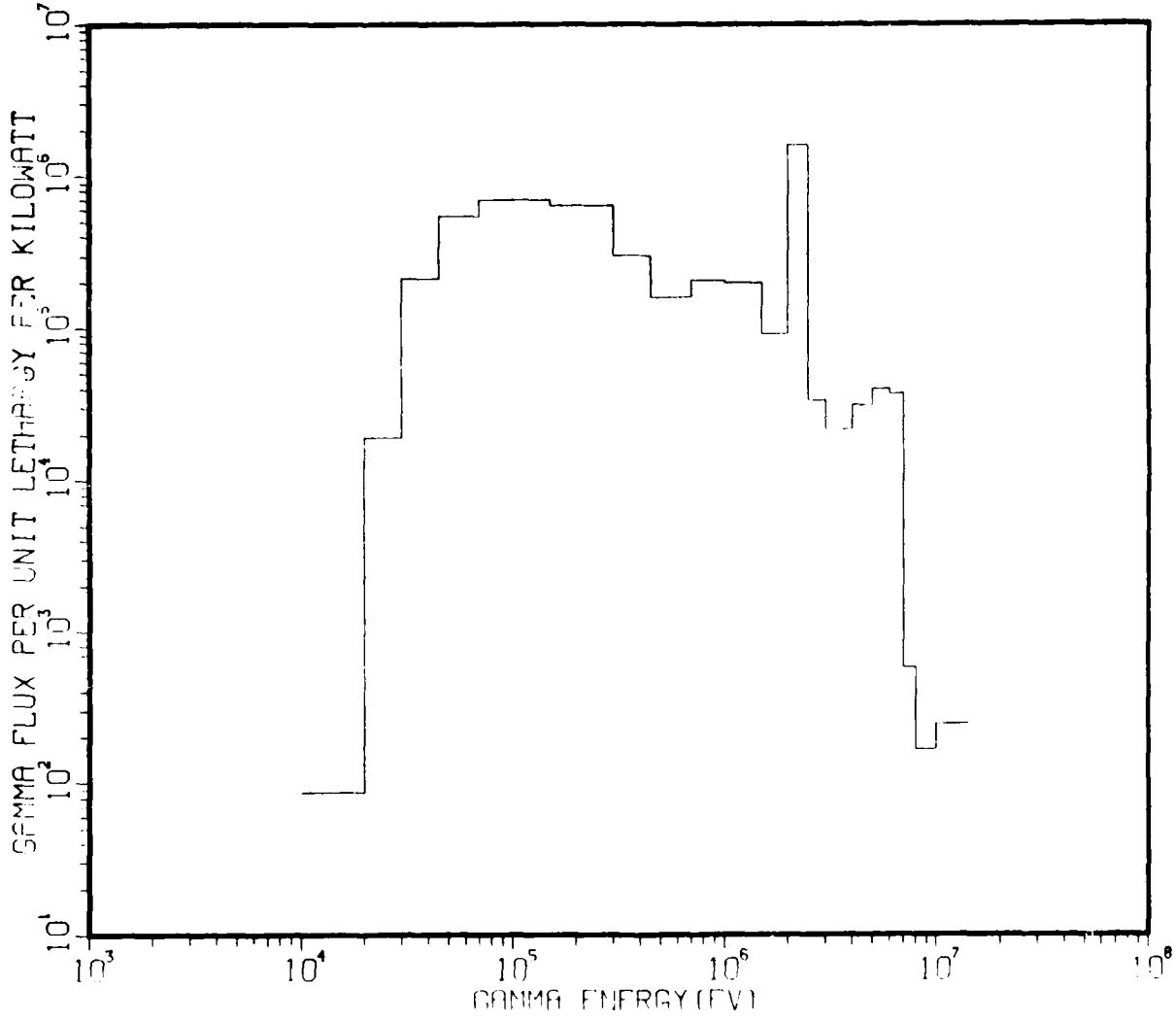

Figure II.3.10. Back Gamma Flux vs Energy ER1 With 6" PB.

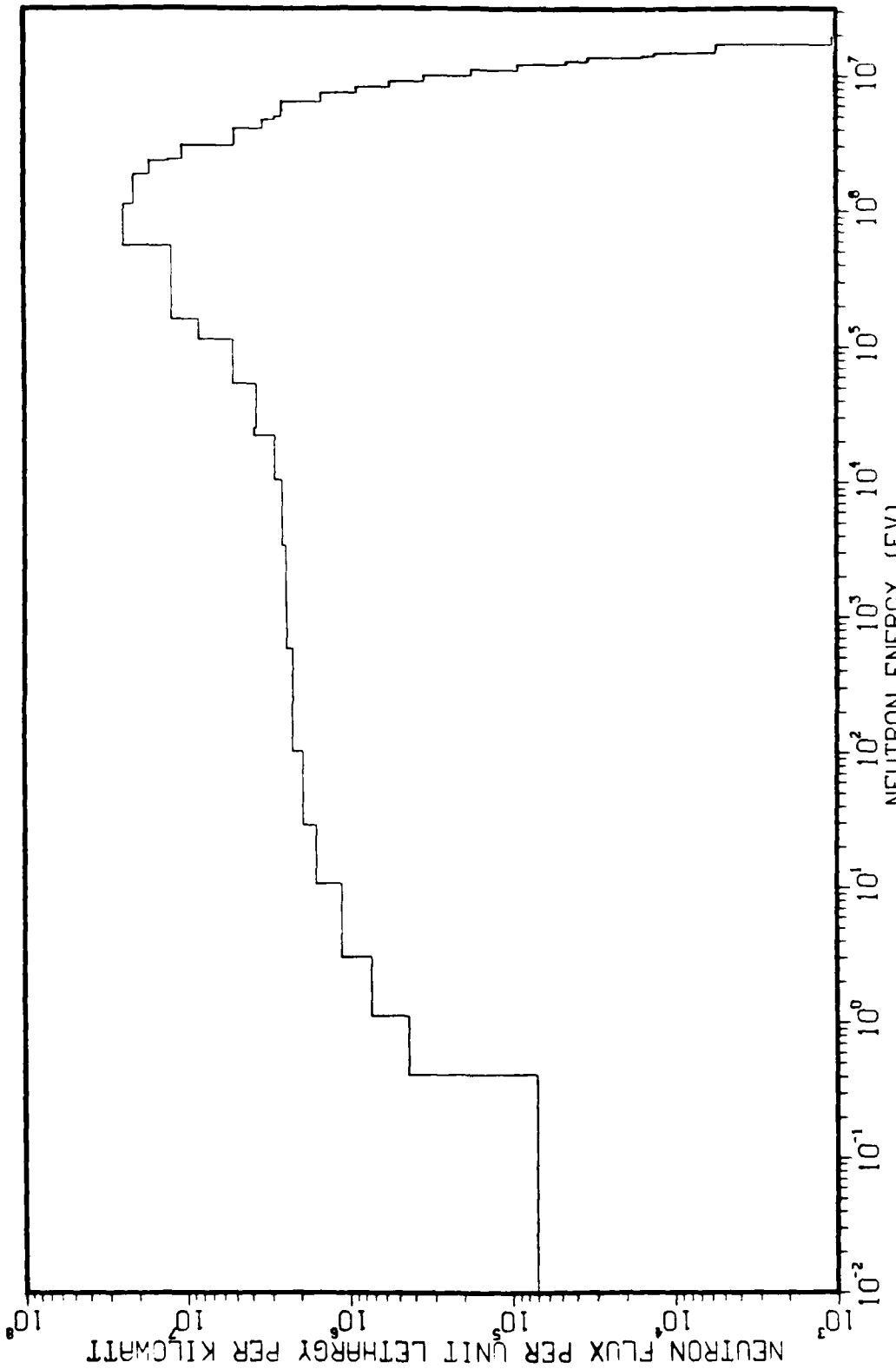

Figure II.3.11. Total (Front+Back, 1-D) Neutron Flux vs Energy ER1 With 6" PB.

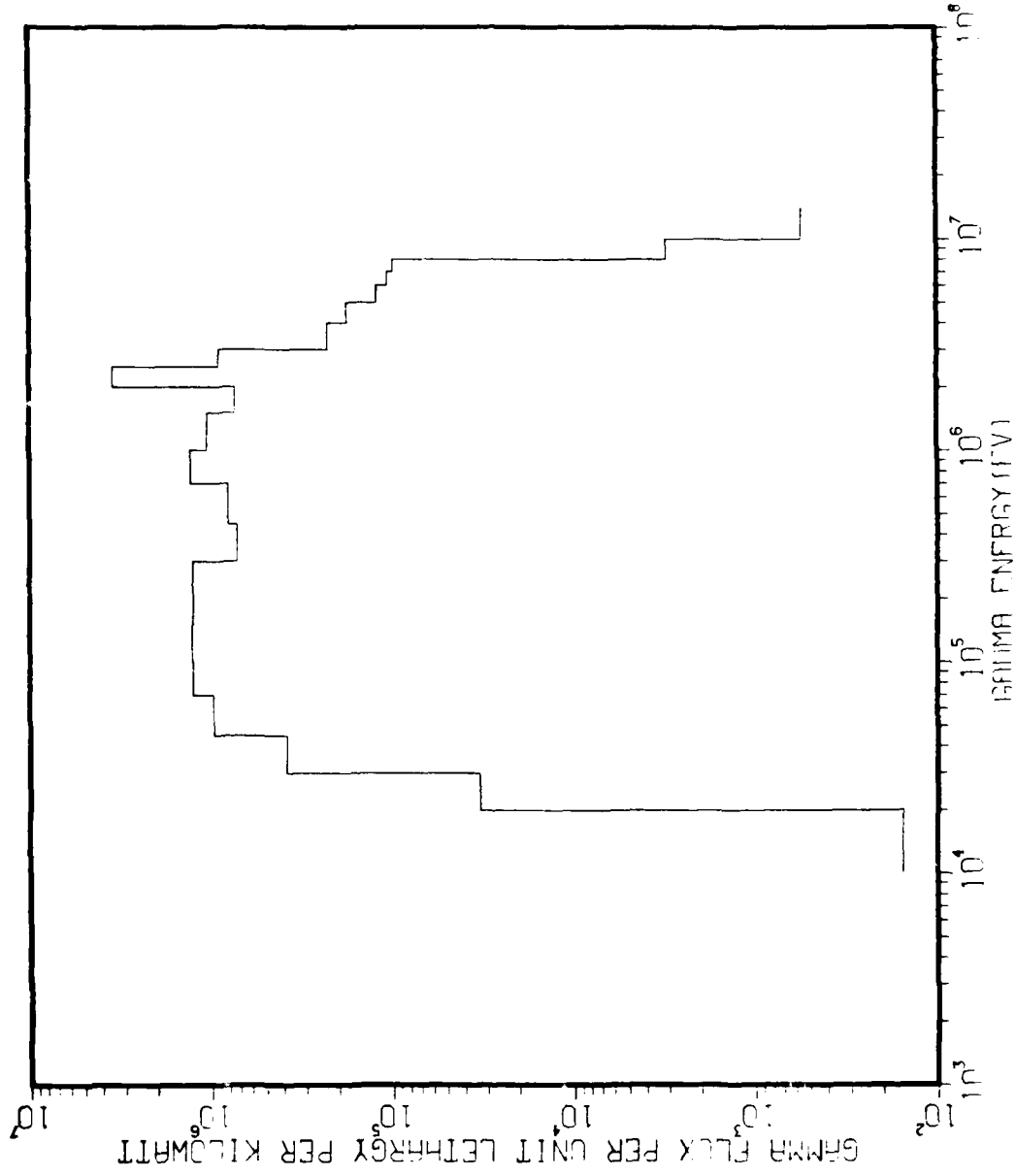

Figure II.3.12. Total (Front+Back) Gamma Flux vs Energy ER1 With 6" PB.

Table II.3.13. Neutron Flux Per Unit Lethargy Per Kilowatt.

ERI WITH 6 IN. PB

GROUP	ENERGY (EV)	FRONT	BACK	TOTAL
1	1.960E+07	1.06E+03	0.00E+00	1.06E+03
2	1.690E+07	5.49E+03	0.00E+00	5.49E+03
3	1.490E+07	1.31E+04	0.00E+00	1.31E+04
4	1.420E+07	1.54E+04	0.00E+00	1.54E+04
5	1.380E+07	3.38E+04	0.00E+00	3.38E+04
6	1.280E+07	4.59E+04	0.00E+00	4.59E+04
7	1.220E+07	9.26E+04	0.00E+00	9.26E+04
8	1.110E+07	1.79E+05	0.00E+00	1.79E+05
9	1.000E+07	3.48E+05	0.00E+00	3.48E+05
10	9.050E+06	5.63E+05	0.00E+00	5.63E+05
11	8.190E+06	9.04E+05	0.00E+00	9.04E+05
12	7.410E+06	1.49E+06	4.75E+01	1.49E+06
13	6.380E+06	2.59E+06	4.20E+02	2.59E+06
14	4.970E+06	2.86E+06	1.91E+03	2.86E+06
15	4.720E+06	3.38E+06	5.99E+03	3.39E+06
16	4.070E+06	5.05E+06	1.26E+04	5.06E+06
17	3.010E+06	1.05E+07	5.94E+04	1.06E+07
18	2.390E+06	1.28E+07	5.73E+04	1.28E+07
19	2.310E+06	1.67E+07	6.79E+04	1.68E+07
20	1.830E+06	2.10E+07	1.31E+05	2.11E+07
21	1.110E+06	2.40E+07	2.52E+05	2.42E+07
22	5.500E+05	1.21E+07	2.32E+05	1.23E+07
23	1.580E+05	8.18E+06	2.13E+05	8.40E+06
24	1.110E+05	5.00E+06	1.67E+05	5.17E+06
25	5.250E+04	3.57E+06	1.43E+05	3.71E+06
26	2.480E+04	3.70E+06	1.38E+05	3.84E+06
27	2.190E+04	2.75E+06	1.34E+05	2.89E+06
28	1.030E+04	2.46E+06	1.34E+05	2.59E+06
29	3.350E+03	2.34E+06	1.39E+05	2.43E+06
30	1.230E+03	2.29E+06	1.45E+05	2.43E+06
31	5.830E+02	2.10E+06	1.49E+05	2.25E+06
32	1.010E+02	1.81E+06	1.50E+05	1.96E+06
33	2.900E+01	1.47E+06	1.47E+05	1.61E+06
34	1.070E+01	9.93E+05	1.39E+05	1.13E+06
35	3.060E+00	6.08E+05	1.31E+05	7.39E+05
36	1.130E+00	3.15E+05	1.23E+05	4.38E+05
37	4.140E-01	3.63E+04	3.40E+04	7.04E+04

Table II.3.14. Gamma Flux Per Unit Lethargy Per Kilowatt

ERI WITH 6 IN. PB

GROUP	ENERGY (EV)	FRONT	BACK	TOTAL
1	1.400E+07	3.15E+02	2.40E+02	5.55E+02
2	1.000E+07	2.94E+03	1.65E+02	3.11E+03
3	8.000E+06	9.80E+04	5.77E+02	9.86E+04
4	7.000E+06	6.93E+04	3.68E+04	1.06E+05
5	6.000E+06	8.16E+04	3.99E+04	1.21E+05
6	5.000E+06	1.46E+05	3.09E+04	1.77E+05
7	4.000E+06	2.06E+05	2.14E+04	2.28E+05
8	3.000E+06	8.69E+05	3.33E+04	9.02E+05
9	2.500E+06	1.86E+06	1.60E+06	3.46E+06
10	2.000E+06	6.44E+05	9.27E+04	7.37E+05
11	1.500E+06	8.41E+05	2.08E+05	1.04E+06
12	1.000E+06	1.09E+06	2.09E+05	1.30E+06
13	7.000E+05	6.44E+05	1.61E+05	8.05E+05
14	4.500E+05	4.18E+05	3.04E+05	7.22E+05
15	3.000E+05	6.23E+05	6.39E+05	1.26E+06
16	1.500E+05	5.69E+05	7.01E+05	1.27E+06
17	1.000E+05	5.55E+05	7.01E+05	1.26E+06
18	7.000E+04	4.27E+05	5.50E+05	9.77E+05
19	4.500E+04	1.68E+05	2.15E+05	3.83E+05
20	3.000E+04	1.42E+04	1.89E+04	3.31E+04
21	2.000E+04	6.90E+01	8.71E+01	1.56E+02

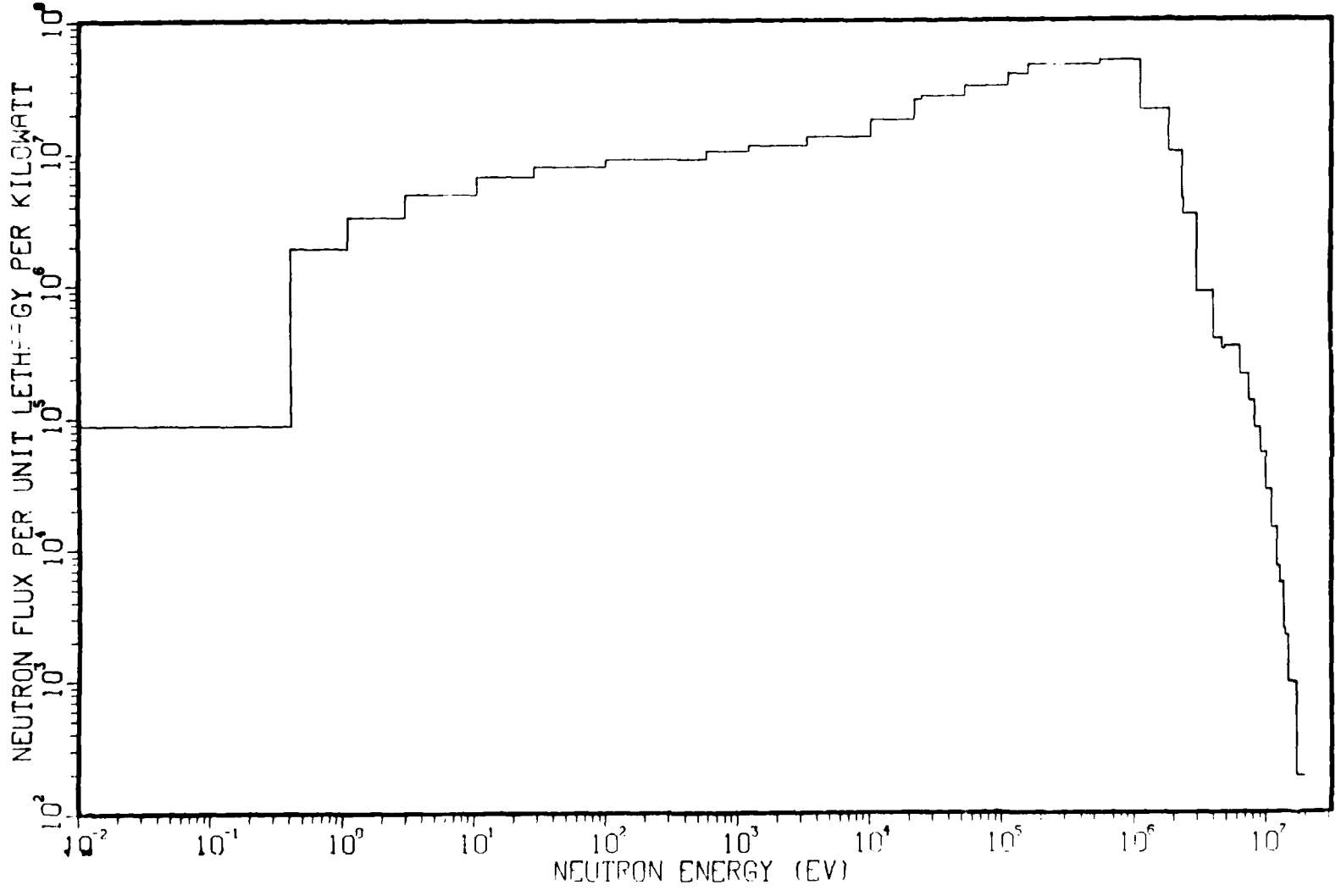

Figure II.3.13. Front (1-D) Neutron Flux vs Energy ER1 With 6" PB and 2" Cave.

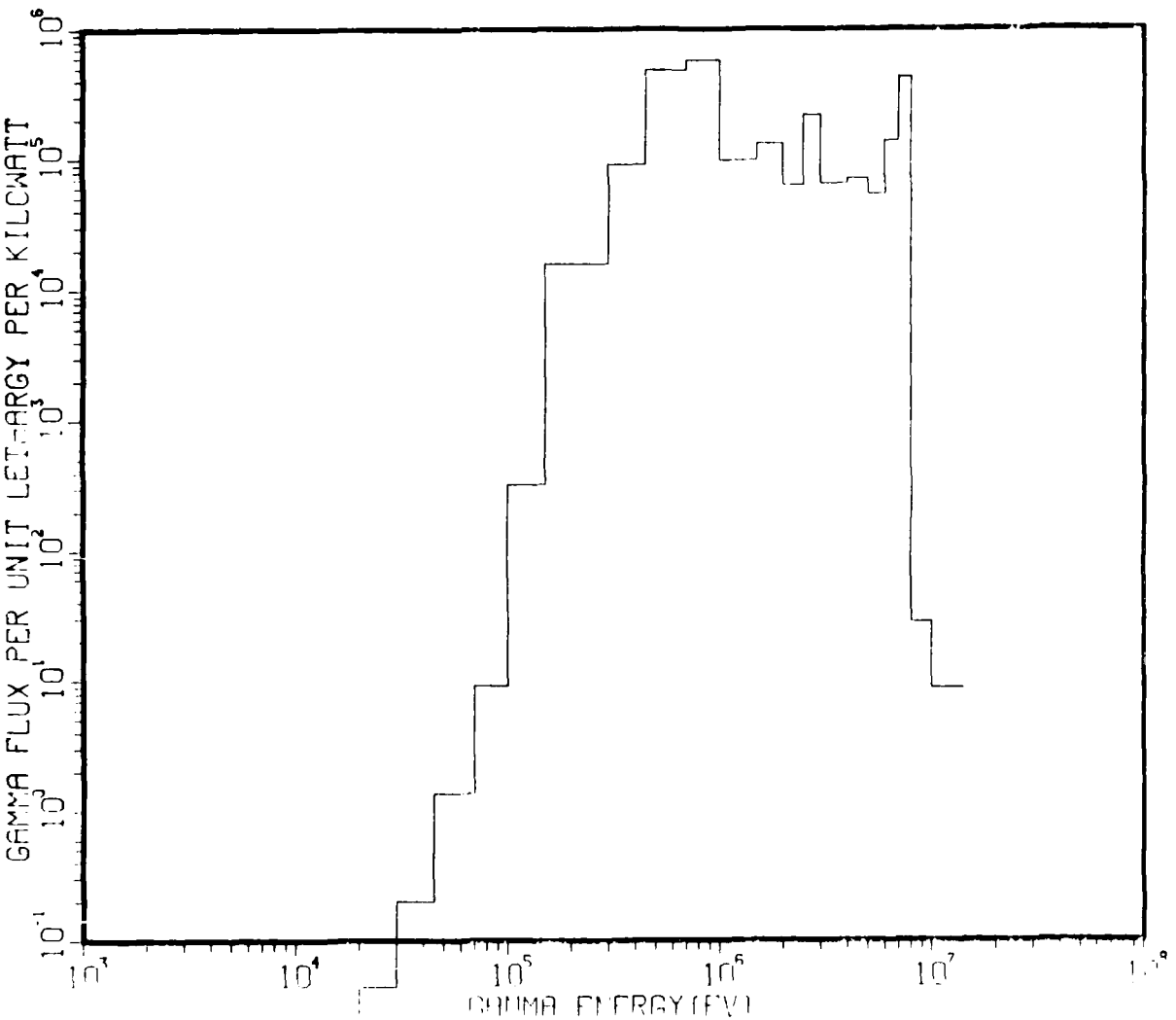

Figure II.3.14. Front Gamma Flux vs Energy ER1 With 6" PB and 2" Cave.

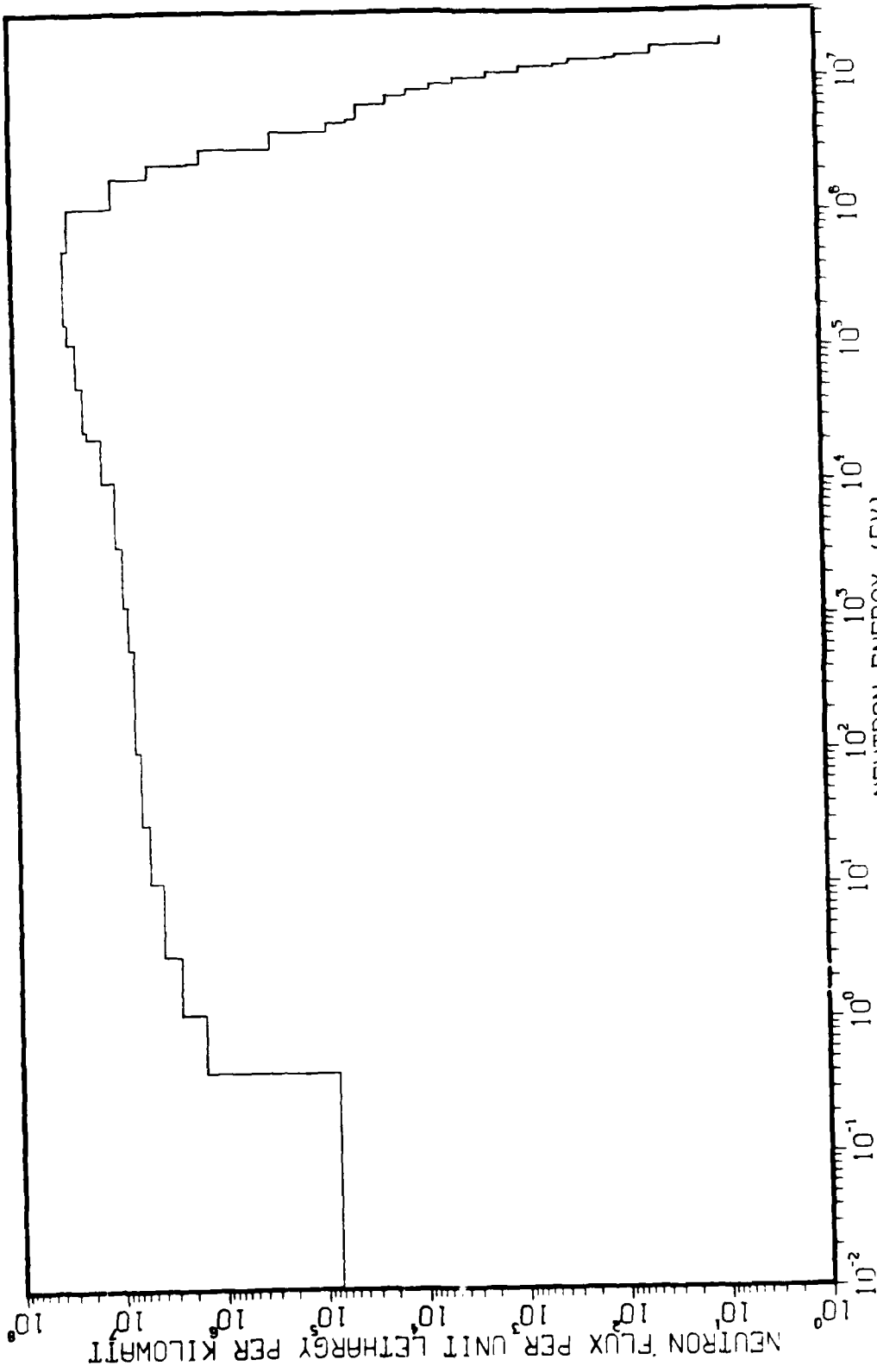

Figure II.3.15. Back (1-D) Neutron Flux vs Energy ER1 With 6" PB and 2" Cave.

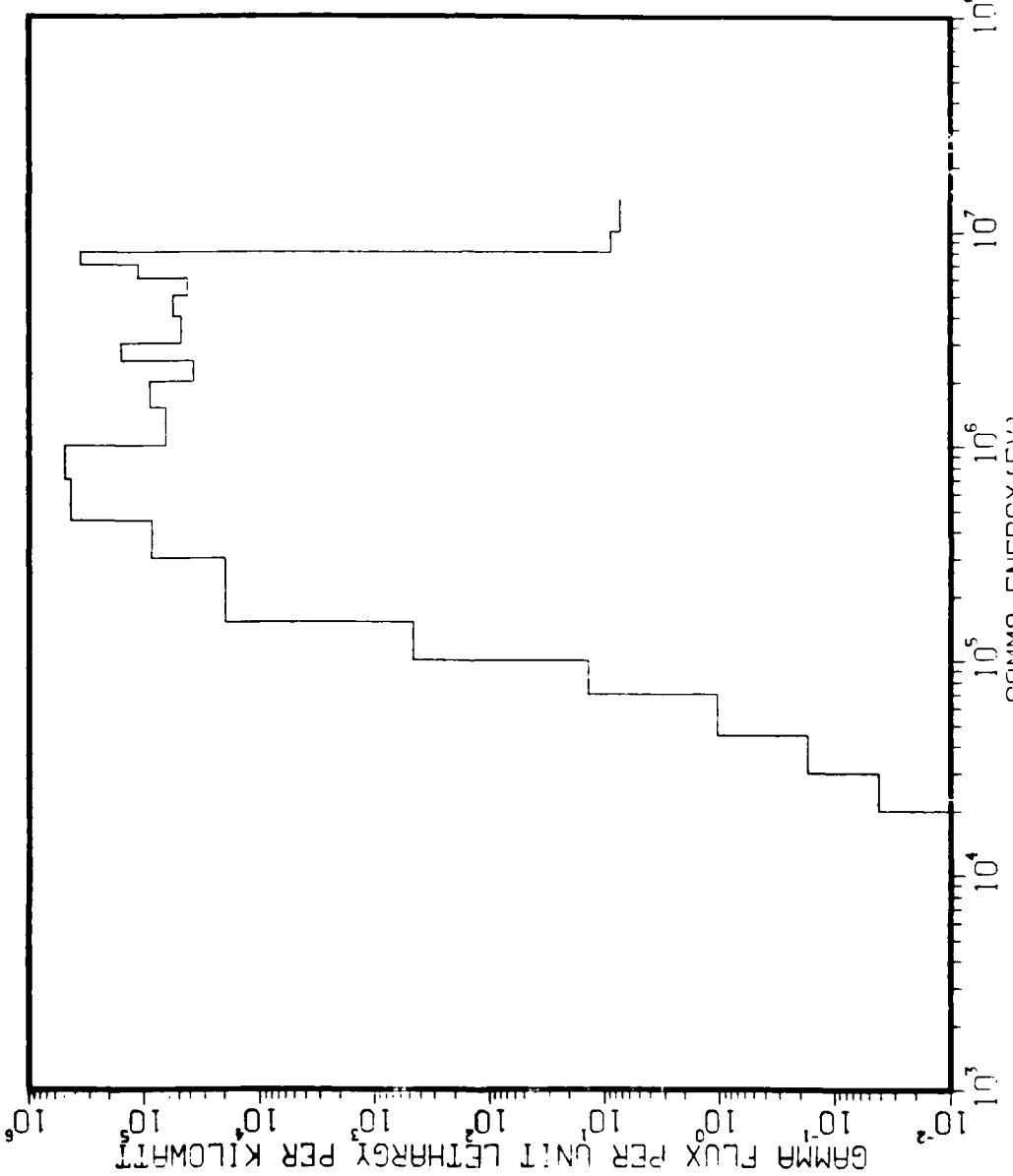

Figure II.3.16. Back Gamma Flux vs Energy ER1 With 6" PB and 2" Cave.

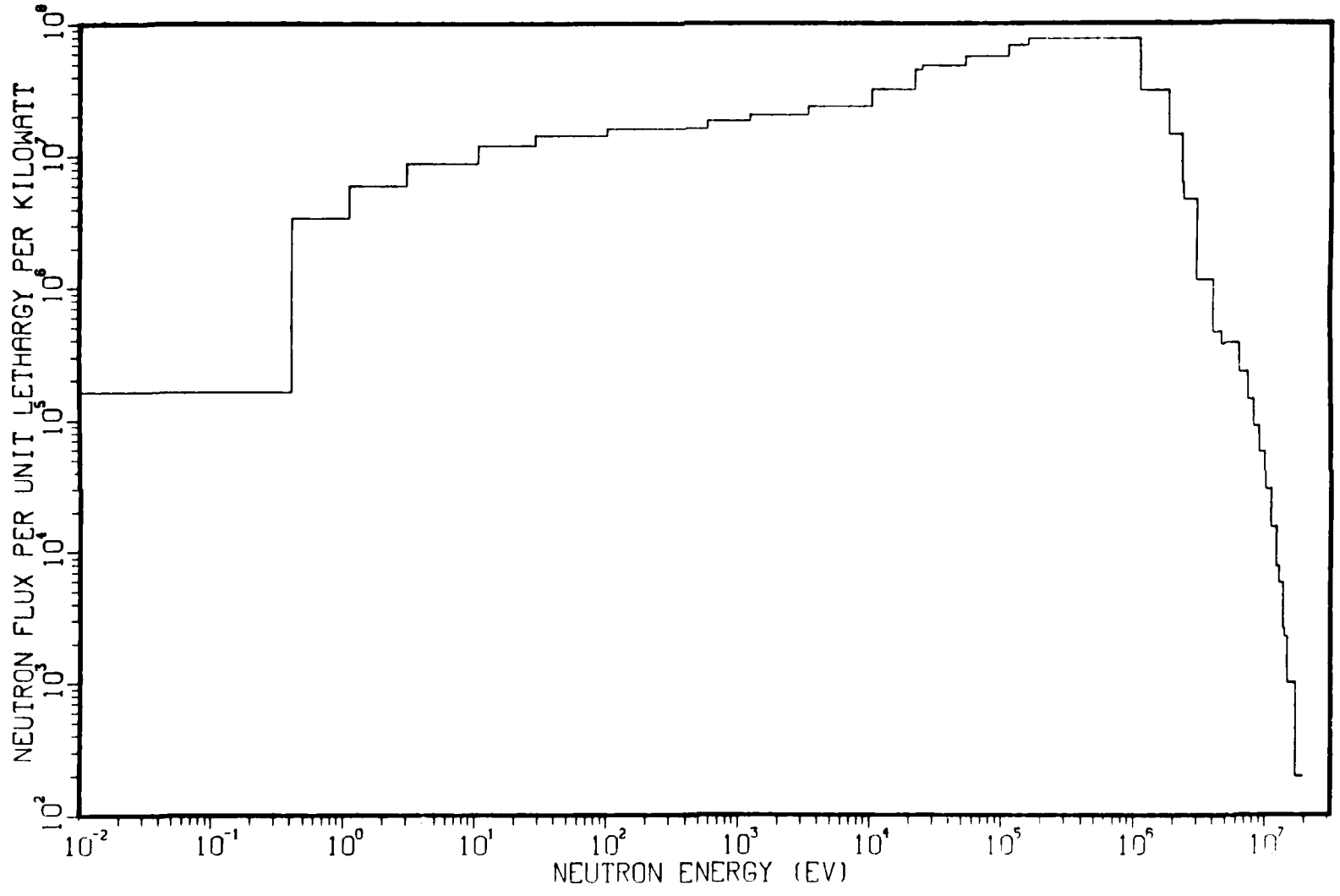

Figure II.3.17. Total (Front+Back, 1-D) Neutron Flux vs Energy ER1 With 6" PB and 2" Cave.

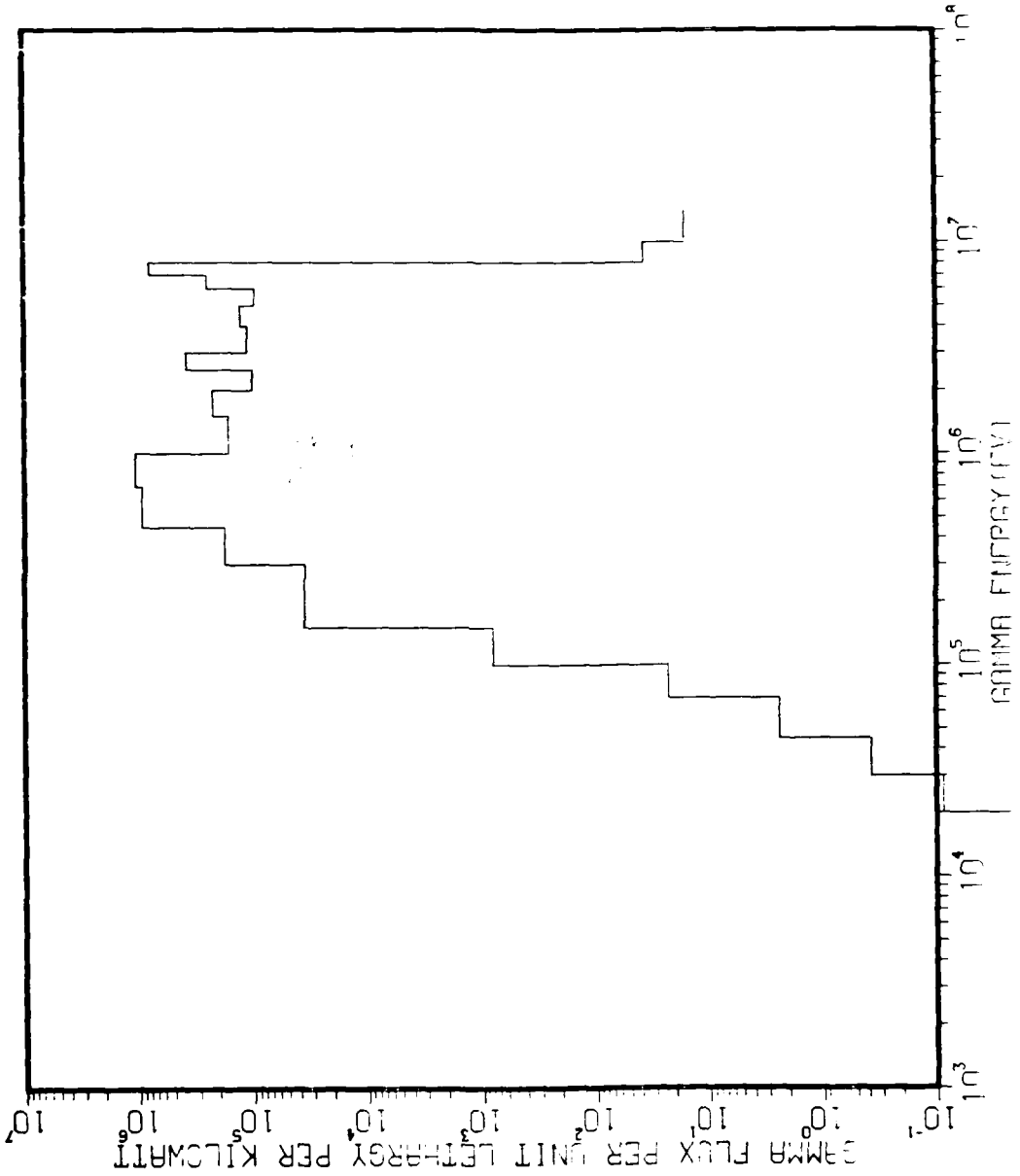

Figure II.3.18. Total (Front+Back) Gamma Flux vs Energy ER1 With 6" PB and 2" Cave.

Table II.3.15. Neutron Flux Per Unit Lethargy Per Killowatt

ER1 WITH 6 IN. PB AND 2 IN. CAVE

GROUP	ENERGY (EV)	FRONT	BACK	TOTAL
1	1.960E+07	1.88E+02	8.82E+00	1.96E+02
2	1.690E+07	9.46E+02	4.31E+01	9.89E+02
3	1.490E+07	2.13E+03	9.50E+01	2.23E+03
4	1.420E+07	2.43E+03	1.19E+02	2.55E+03
5	1.380E+07	5.38E+03	2.74E+02	5.65E+03
6	1.280E+07	7.13E+03	3.87E+02	7.52E+03
7	1.220E+07	1.42E+04	8.56E+02	1.51E+04
8	1.110E+07	2.74E+04	1.82E+03	2.92E+04
9	1.000E+07	5.27E+04	3.91E+03	5.66E+04
10	9.050E+06	8.23E+04	6.64E+03	8.89E+04
11	8.190E+06	1.32E+05	1.11E+04	1.43E+05
12	7.410E+06	2.13E+05	1.83E+04	2.31E+05
13	6.380E+06	3.45E+05	3.60E+04	3.81E+05
14	4.970E+06	3.31E+05	4.42E+04	3.75E+05
15	4.720E+06	3.98E+05	6.96E+04	4.68E+05
16	4.070E+06	9.01E+05	2.55E+05	1.16E+06
17	3.010E+06	3.43E+06	1.29E+06	4.72E+06
18	2.390E+06	4.51E+06	1.70E+06	6.21E+06
19	2.310E+06	1.02E+07	4.27E+06	1.45E+07
20	1.830E+06	2.12E+07	9.81E+06	3.10E+07
21	1.110E+06	4.97E+07	2.73E+07	7.69E+07
22	5.500E+05	4.61E+07	3.08E+07	7.69E+07
23	1.580E+05	3.93E+07	2.89E+07	6.82E+07
24	1.110E+05	3.18E+07	2.42E+07	5.60E+07
25	5.250E+04	2.70E+07	2.07E+07	4.77E+07
26	2.480E+04	2.54E+07	1.90E+07	4.44E+07
27	2.190E+04	1.79E+07	1.38E+07	3.17E+07
28	1.030E+04	1.33E+07	1.02E+07	2.35E+07
29	3.350E+03	1.15E+07	8.83E+06	2.03E+07
30	1.230E+03	1.03E+07	7.89E+06	1.82E+07
31	5.830E+02	9.08E+06	6.91E+06	1.60E+07
32	1.010E+02	8.00E+06	6.10E+06	1.41E+07
33	2.900E+01	6.75E+06	5.16E+06	1.19E+07
34	1.070E+01	4.92E+06	3.78E+06	8.70E+06
35	3.060E+00	3.34E+06	2.59E+06	5.93E+06
36	1.130E+00	1.92E+06	1.50E+06	3.42E+06
37	4.140E-01	8.79E+04	7.45E+04	1.62E+05

Table II.3.16. Gamma Flux Per Unit Lethargy Per Kilowatt.

ER1 WITH 6 IN. PB AND 2 IN. CAVE

GROUP	ENERGY (EV)	FRONT	BACK	TOTAL
1	1.400E+07	8.65E+00	7.22E+00	1.59E+01
2	1.000E+07	2.80E+01	8.67E+00	3.67E+01
3	8.000E+06	4.28E+05	3.56E+05	7.84E+05
4	7.000E+06	1.38E+05	1.12E+05	2.50E+05
5	6.000E+06	5.39E+04	4.16E+04	9.55E+04
6	5.000E+06	7.18E+04	5.54E+04	1.27E+05
7	4.000E+06	6.50E+04	4.68E+04	1.12E+05
8	3.000E+06	2.20E+05	1.56E+05	3.76E+05
9	2.500E+06	6.32E+04	3.71E+04	1.00E+05
10	2.000E+06	1.32E+05	8.85E+04	2.20E+05
11	1.500E+06	9.86E+04	6.44E+04	1.63E+05
12	1.000E+06	5.75E+05	4.91E+05	1.07E+06
13	7.000E+05	4.86E+05	4.39E+05	9.25E+05
14	4.500E+05	9.04E+04	8.57E+04	1.76E+05
15	3.000E+05	1.58E+04	1.97E+04	3.56E+04
16	1.500E+05	3.25E+02	4.62E+02	7.87E+02
17	1.000E+05	9.14E+00	1.37E+01	2.29E+01
18	7.000E+04	1.36E+00	1.06E+00	2.42E+00
19	4.500E+04	2.01E-01	1.74E-01	3.75E-01
20	3.000E+04	4.48E-02	4.20E-02	8.68E-02
21	2.000E+04	1.15E-02	9.85E-03	2.14E-02

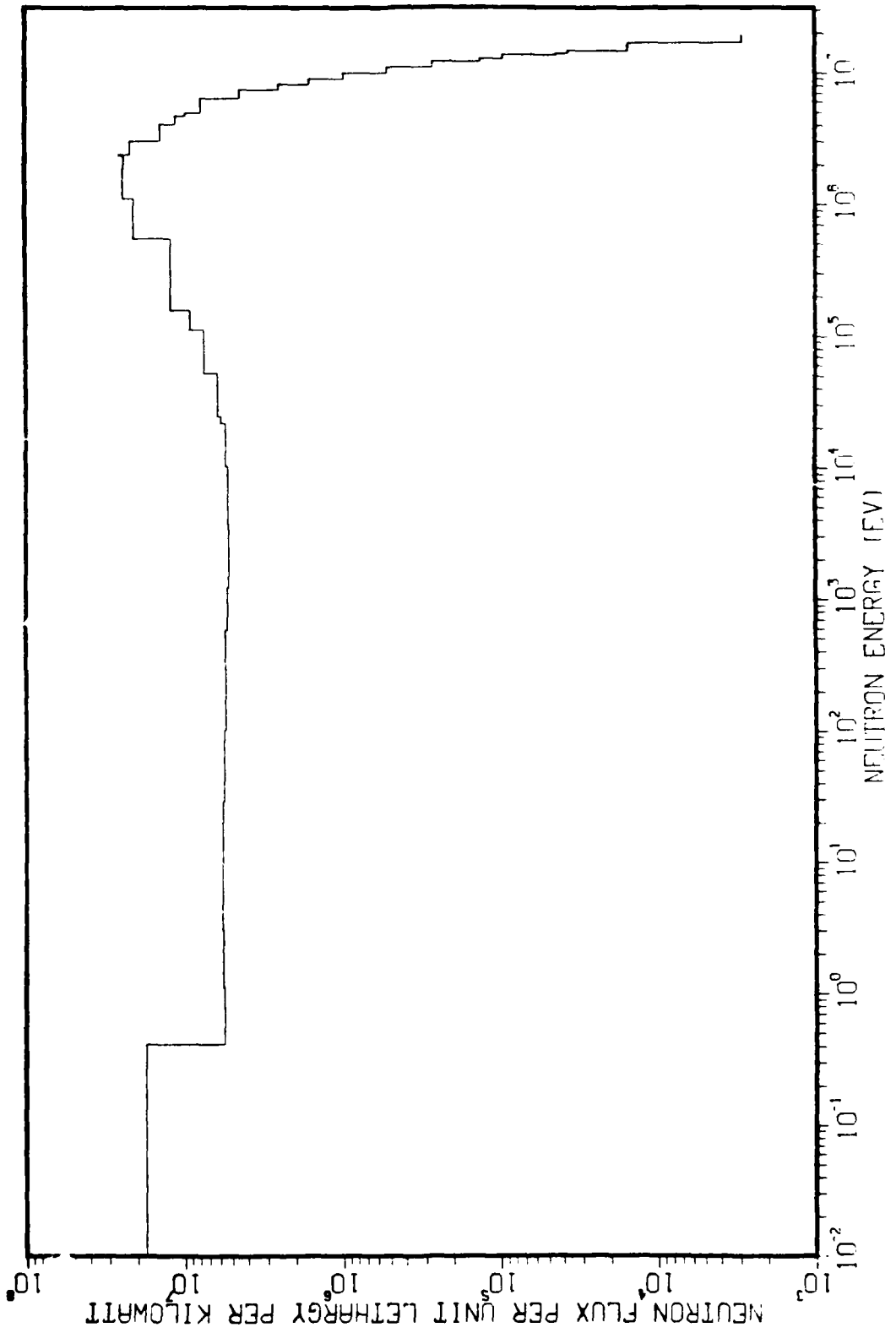

Figure II.3.19. Front (1-D) Neutron Flux vs Energy ERI With 2" PB and Exercise Wheel.

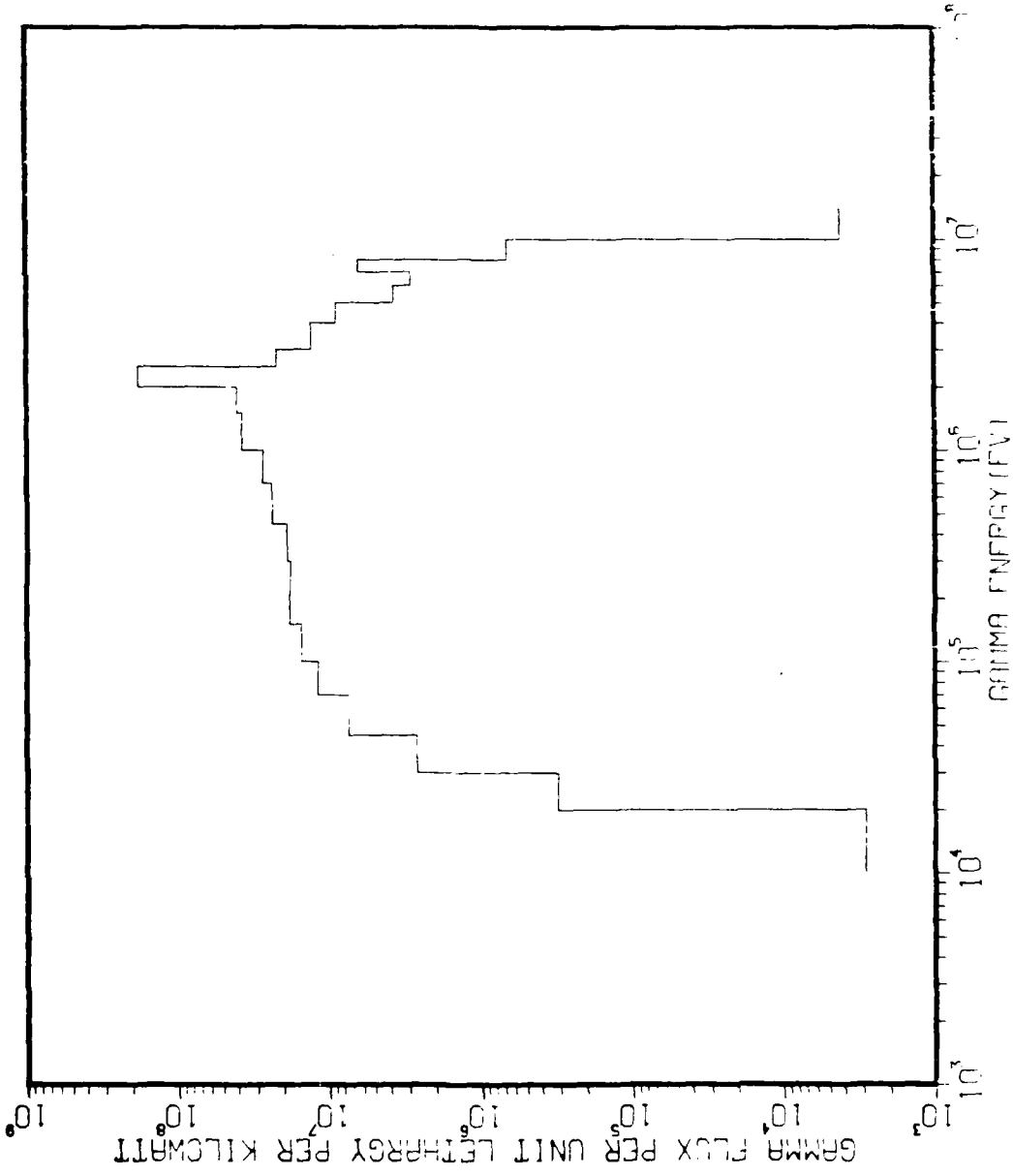

Figure II.3.20. Front Gamma Flux vs Energy ER1 With 2" PB and Exercise Wheel.

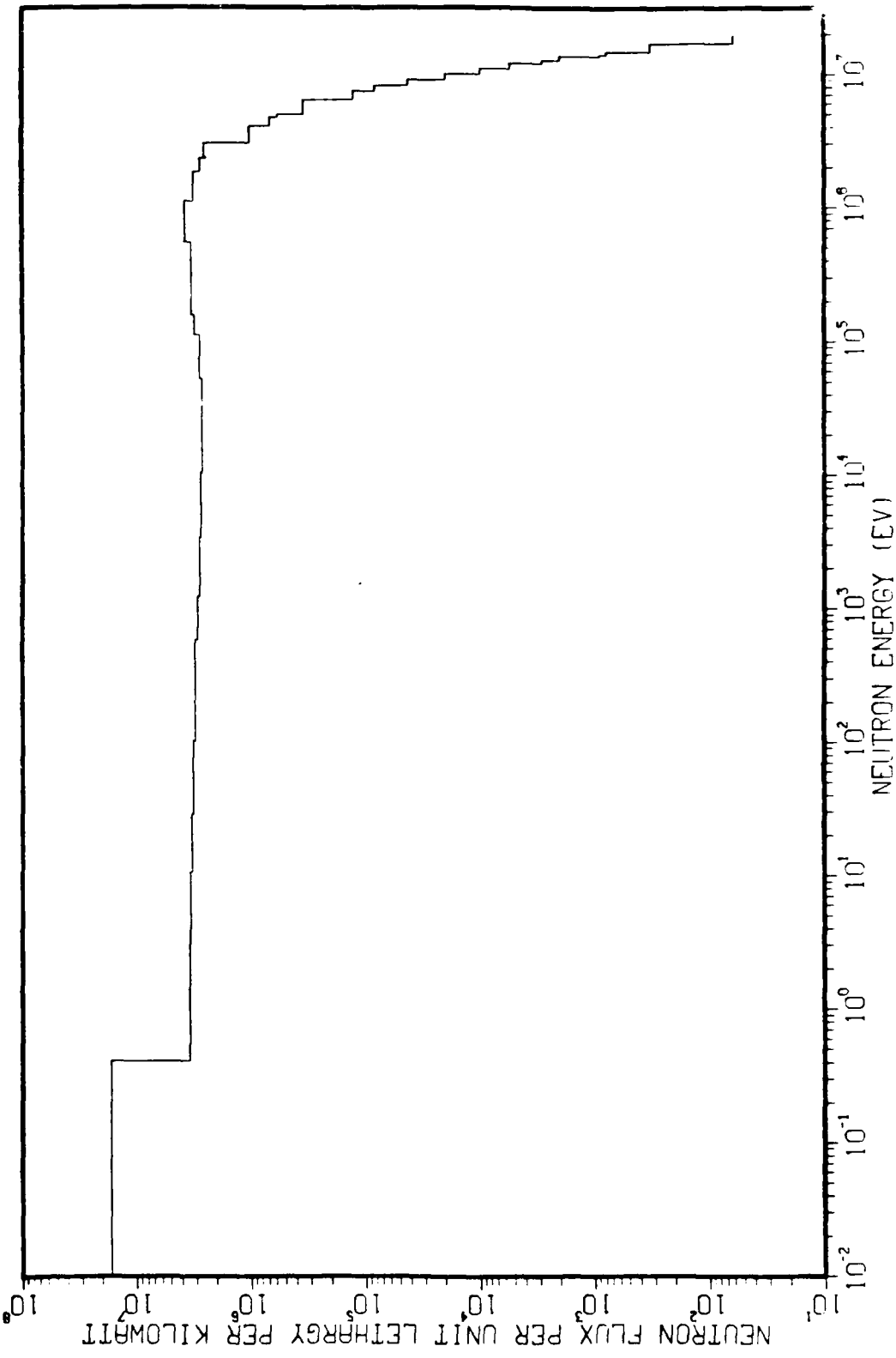

Figure II.3.21. Back (1-D) Neutron Flux vs Energy ERI With 2" PB and Exercise Wheel.

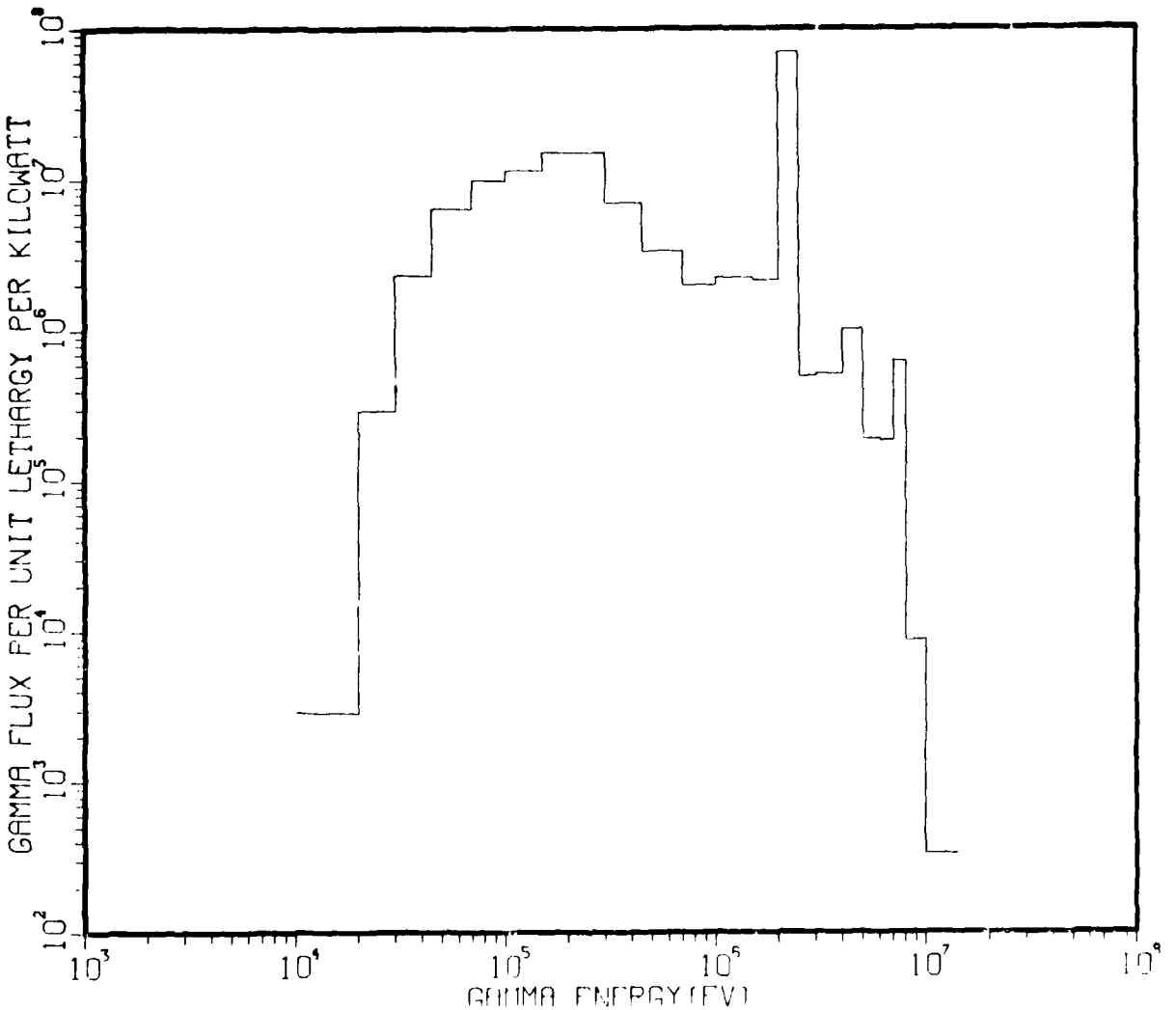

Figure II.3.22. Back Gamma Flux vs Energy ER1 With 2" PB and Exercise Wheel.

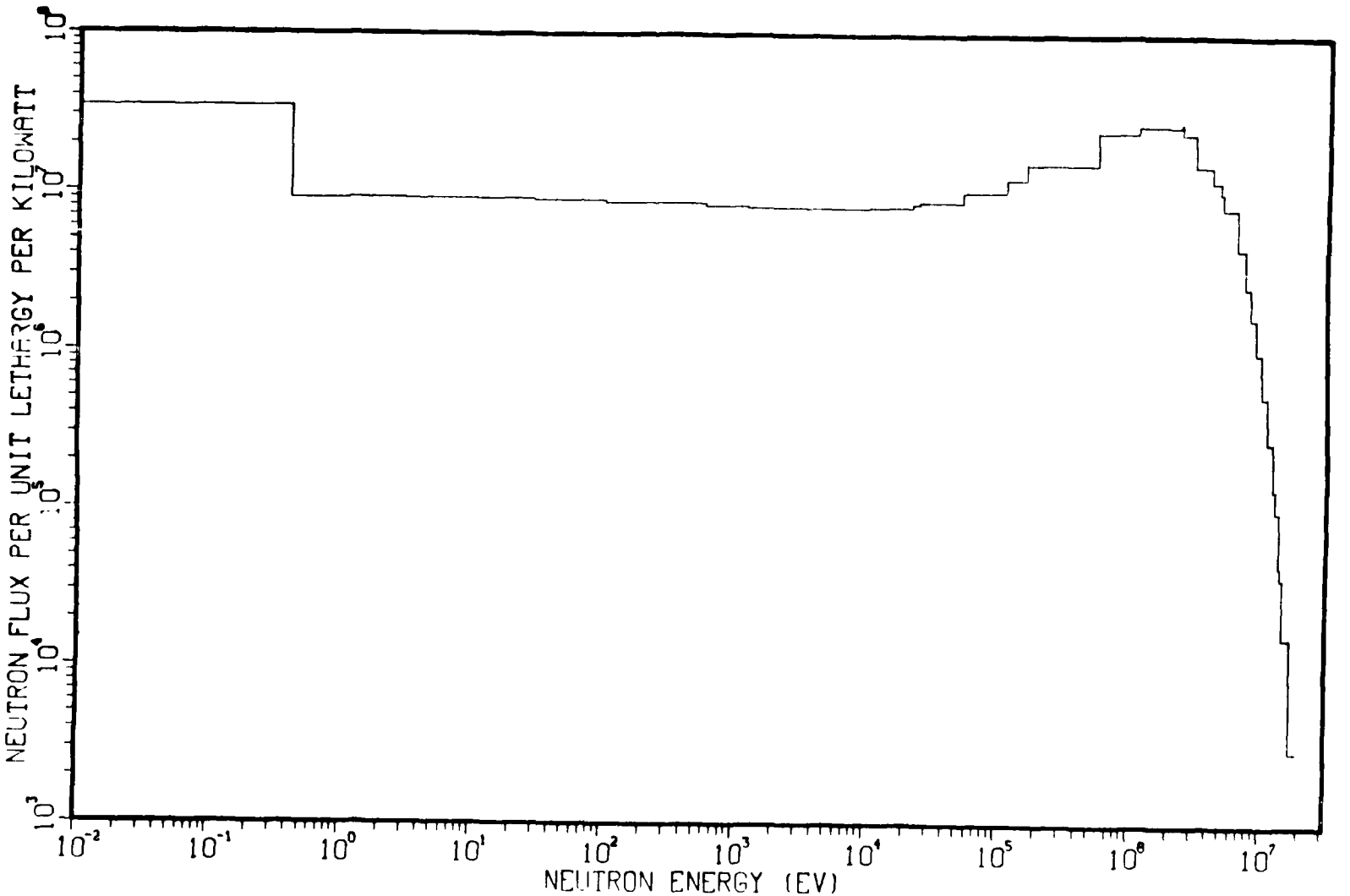

Figure II.3.23. Total (Front+Back, 1-D) Neutron Flux vs Energy ER1 With 2" PB and Exercise Wheel.

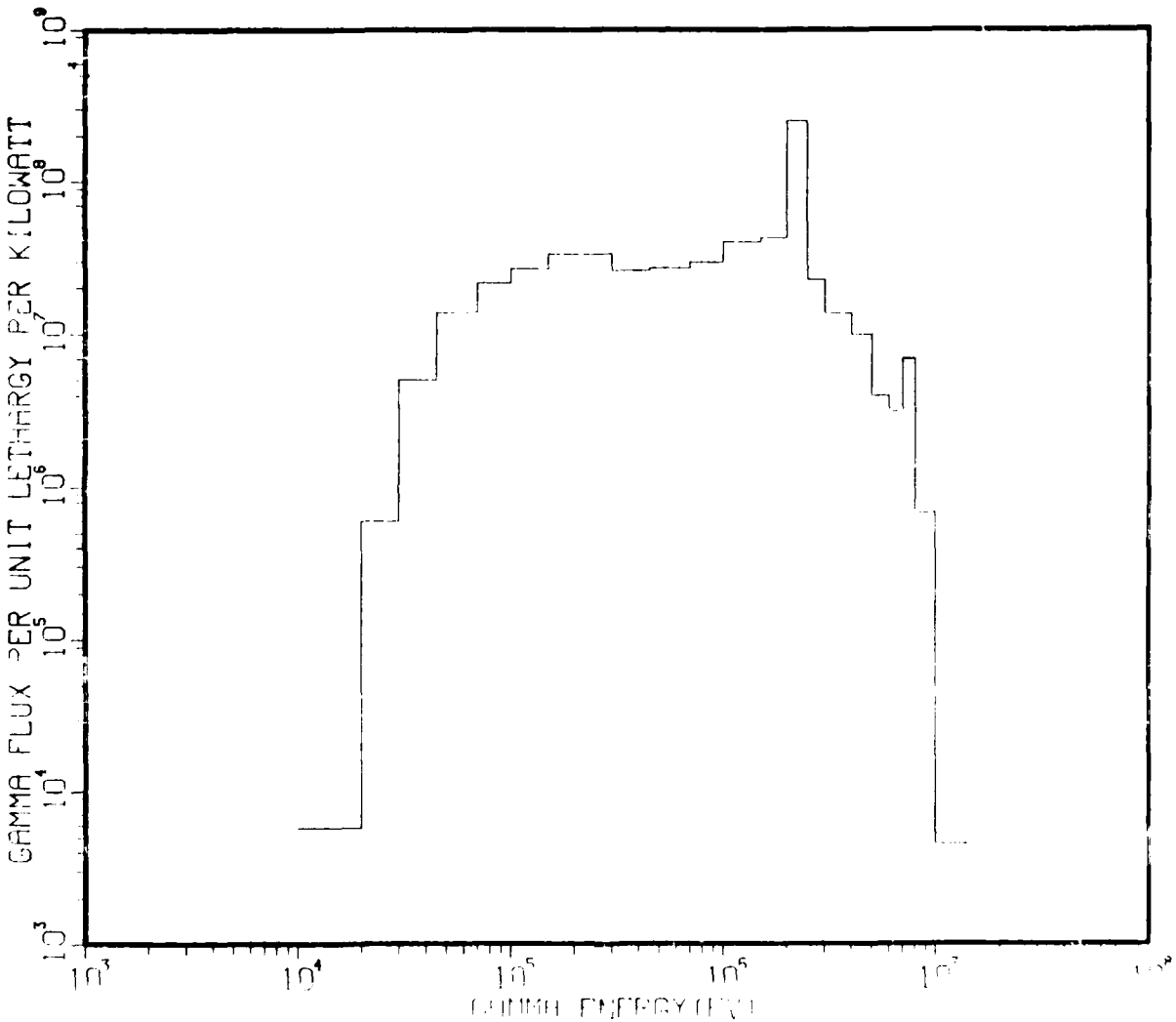

Figure II.3.24. Total (Front+Back) Gamma Flux vs Energy ER1 With 2" PB and Exercise Wheel.

Table II.3.17. Neutron Flux Per Unit Lethargy Per Kilowatt.

ER1 WITH 2 IN. PB AND EXERCISE WHEEL

GROUP	ENERGY (EV)	FRONT	BACK	TOTAL
1	1.960E+07	2.90E+03	6.16E+01	2.96E+03
2	1.690E+07	1.51E+04	3.29E+02	1.54E+04
3	1.490E+07	3.63E+04	8.02E+02	3.71E+04
4	1.420E+07	4.33E+04	9.11E+02	4.42E+04
5	1.380E+07	9.49E+04	2.04E+03	9.69E+04
6	1.280E+07	1.32E+05	2.89E+03	1.35E+05
7	1.220E+07	2.65E+05	5.45E+03	2.70E+05
8	1.110E+07	5.15E+05	9.97E+03	5.25E+05
9	1.000E+07	9.78E+05	1.99E+04	9.98E+05
10	9.050E+06	1.63E+06	4.17E+04	1.67E+06
11	8.190E+06	2.51E+06	8.16E+04	2.59E+06
12	7.410E+06	4.42E+06	1.26E+05	4.55E+06
13	6.380E+06	7.85E+06	3.46E+05	8.20E+06
14	4.970E+06	9.77E+06	5.79E+05	1.04E+07
15	4.720E+06	1.14E+07	6.77E+05	1.21E+07
16	4.070E+06	1.40E+07	1.02E+06	1.50E+07
17	3.010E+06	2.18E+07	2.51E+06	2.43E+07
18	2.390E+06	2.56E+07	2.40E+06	2.80E+07
19	2.310E+06	2.41E+07	2.75E+06	2.69E+07
20	1.830E+06	2.42E+07	3.14E+06	2.73E+07
21	1.110E+06	2.08E+07	3.71E+06	2.45E+07
22	5.500E+05	1.22E+07	3.26E+06	1.54E+07
23	1.580E+05	9.20E+06	3.07E+06	1.23E+07
24	1.110E+05	7.47E+06	2.79E+06	1.03E+07
25	5.250E+04	6.21E+06	2.67E+06	8.88E+06
26	2.460E+04	5.88E+06	2.68E+06	8.56E+06
27	2.190E+04	5.53E+06	2.65E+06	8.18E+06
28	1.030E+04	5.33E+06	2.73E+06	8.07E+06
29	3.350E+03	5.30E+06	2.83E+06	8.13E+06
30	1.230E+03	5.41E+06	2.94E+06	8.35E+06
31	5.830E+02	5.54E+06	3.03E+06	8.57E+06
32	1.010E+02	5.70E+06	3.22E+06	8.92E+06
33	2.900E+01	5.79E+06	3.32E+06	9.11E+06
34	1.070E+01	5.78E+06	3.39E+06	9.17E+06
35	3.060E+00	5.76E+06	3.47E+06	9.22E+06
36	1.130E+00	5.60E+06	3.48E+06	9.08E+06
37	4.140E-01	1.77E+07	1.67E+07	3.44E+07

Table II.3.18. Gamma Flux Per Unit Lethargy Per Kilowatt.

ER1 WITH 2 IN. PB AND EXERCISE WHEEL

GROUP	ENERGY (EV)	FRONT	BACK	TOTAL
1	1.400E+07	4.17E+03	3.32E-02	4.51E+03
2	1.000E+07	6.70E+05	8.66E+03	6.79E+05
3	8.000E+06	6.32E+06	6.24E-05	6.95E+06
4	7.000E+06	2.93E+06	1.83E-05	3.12E+06
5	6.000E+06	3.77E+06	1.88E-05	3.96E+06
6	5.000E+06	8.95E+06	1.00E+06	9.95E+06
7	4.000E+06	1.32E+07	5.12E-05	1.37E+07
8	3.000E+06	2.21E+07	4.90E-05	2.26E+07
9	2.500E+06	1.80E+08	6.96E-07	2.50E+08
10	2.000E+06	4.07E+07	2.13E-06	4.29E+07
11	1.500E+06	3.79E+07	2.23E-06	4.62E+07
12	1.000E+06	2.74E+07	1.98E-06	2.94E+07
13	7.000E+05	2.38E+07	3.32E+06	2.71E+07
14	4.500E+05	1.90E+07	6.99E+06	2.60E+07
15	3.000E+05	1.82E+07	1.51E-07	3.32E+07
16	1.500E+05	1.53E+07	1.14E+07	2.67E+07
17	1.000E+05	1.19E+07	9.85E+06	2.17E+07
18	7.000E+04	7.46E+06	6.42E+06	1.39E+07
19	4.500E+04	2.69E+06	2.31E+06	5.01E+06
20	3.000E+04	3.11E+05	2.91E+05	6.02E+05
21	2.000E+04	2.88E+03	2.86E-03	5.74E+03

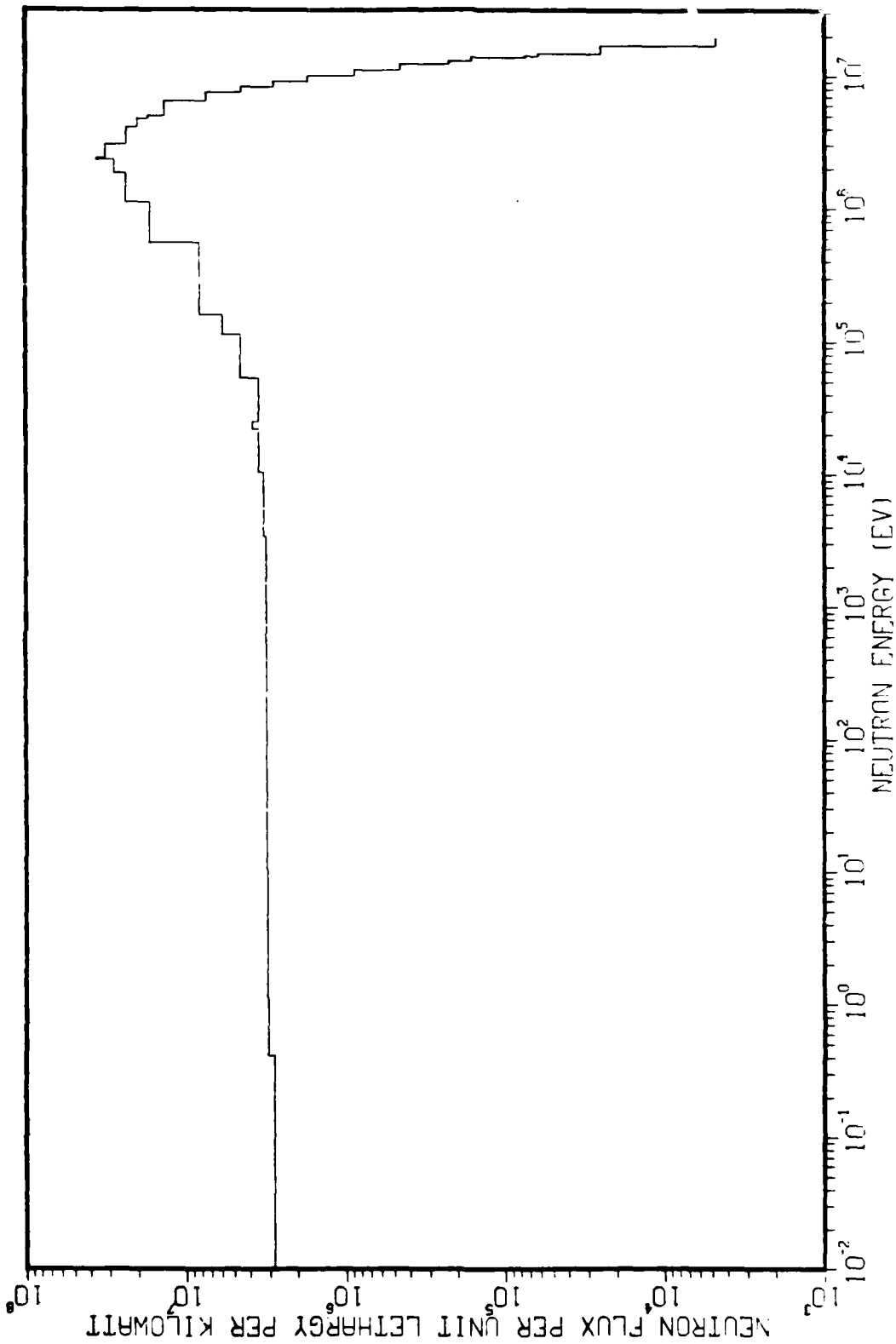

Figure II.3.25. Front (1-D) Neutron Flux vs Energy ER2 Free Field.

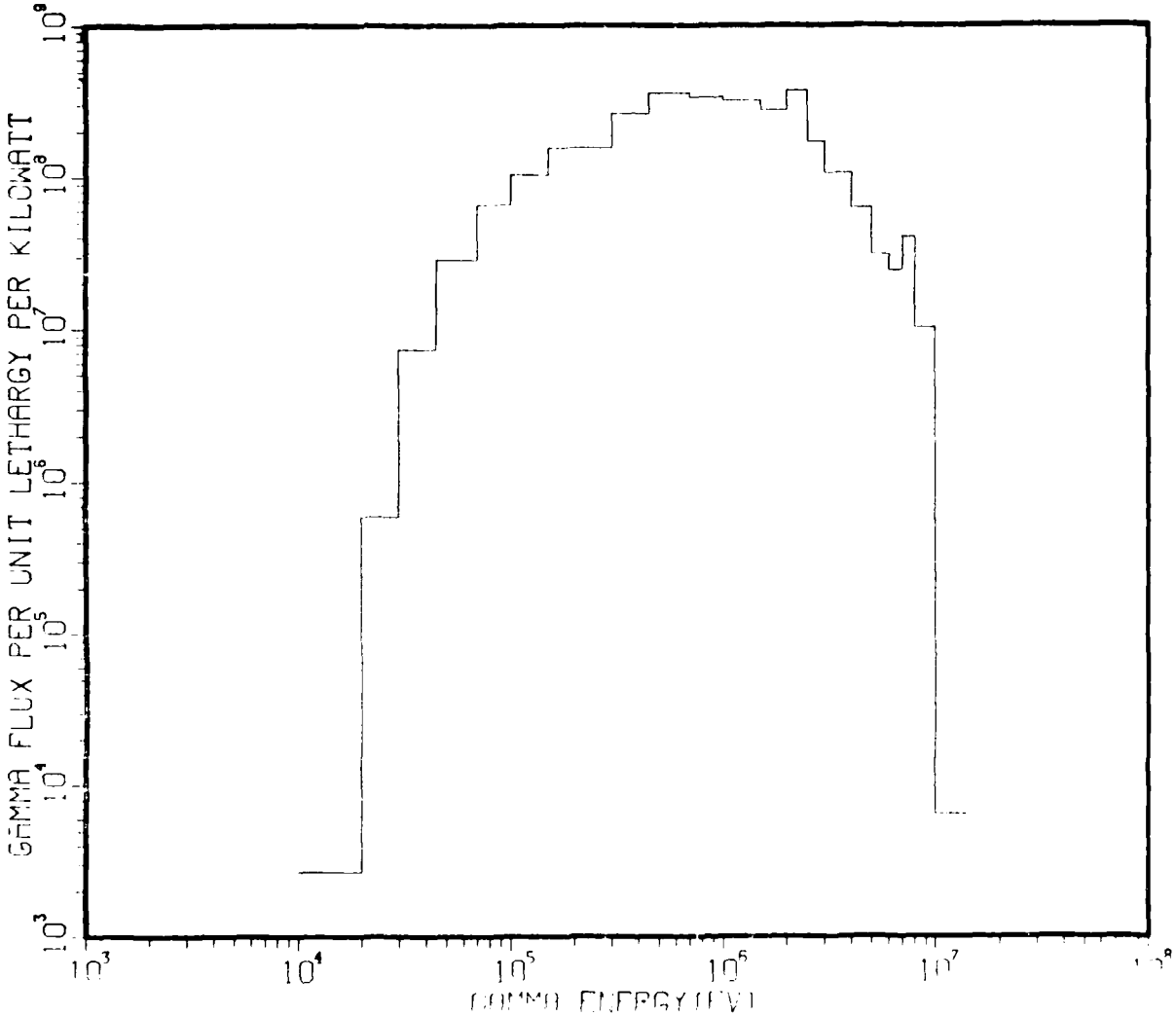

Figure II.3.26. Front Gamma Flux vs Energy ER2 Free Field.

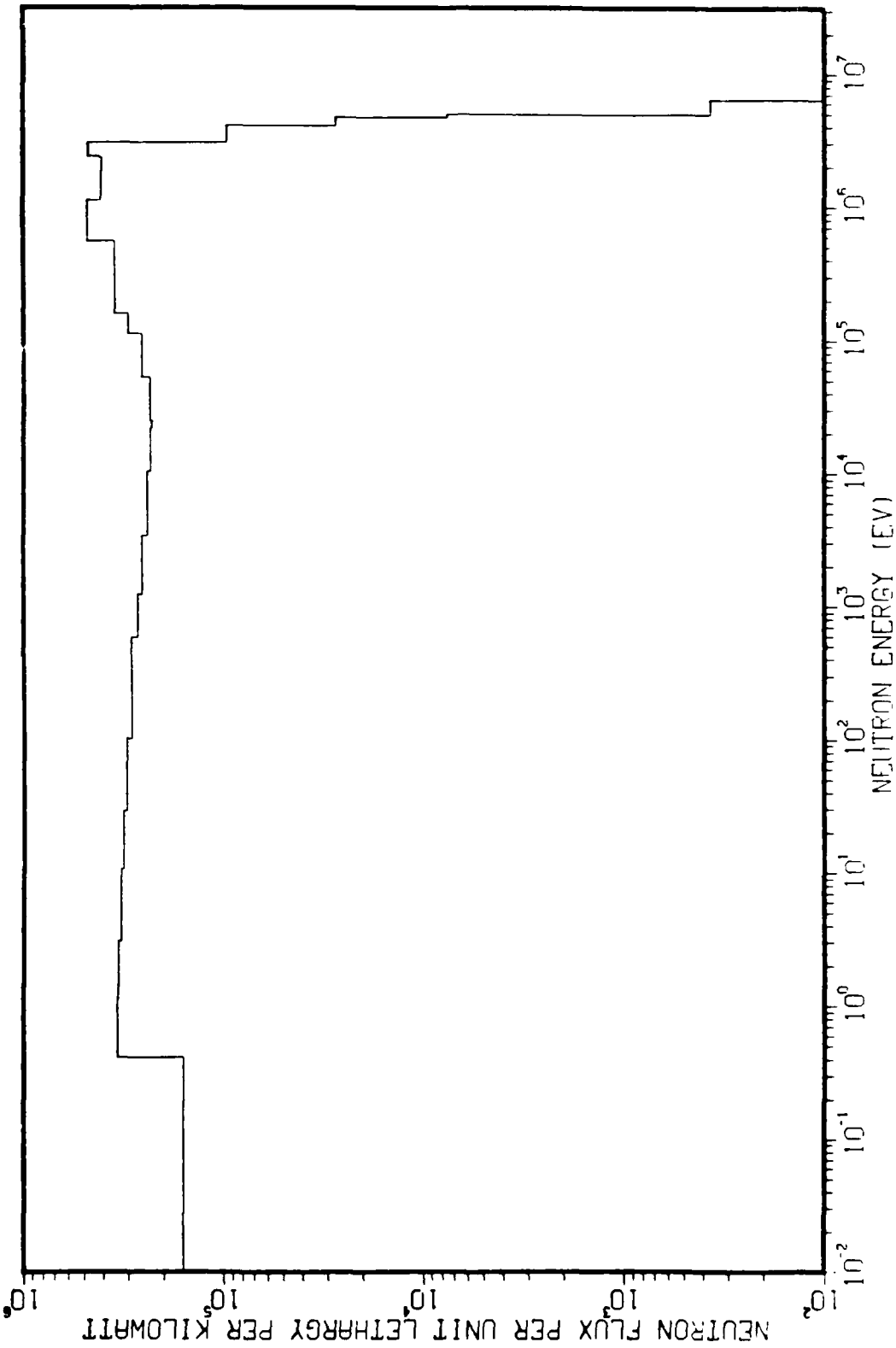

Figure II.3.27. Back (1-D) Neutron Flux vs Energy ER2 Free Field.

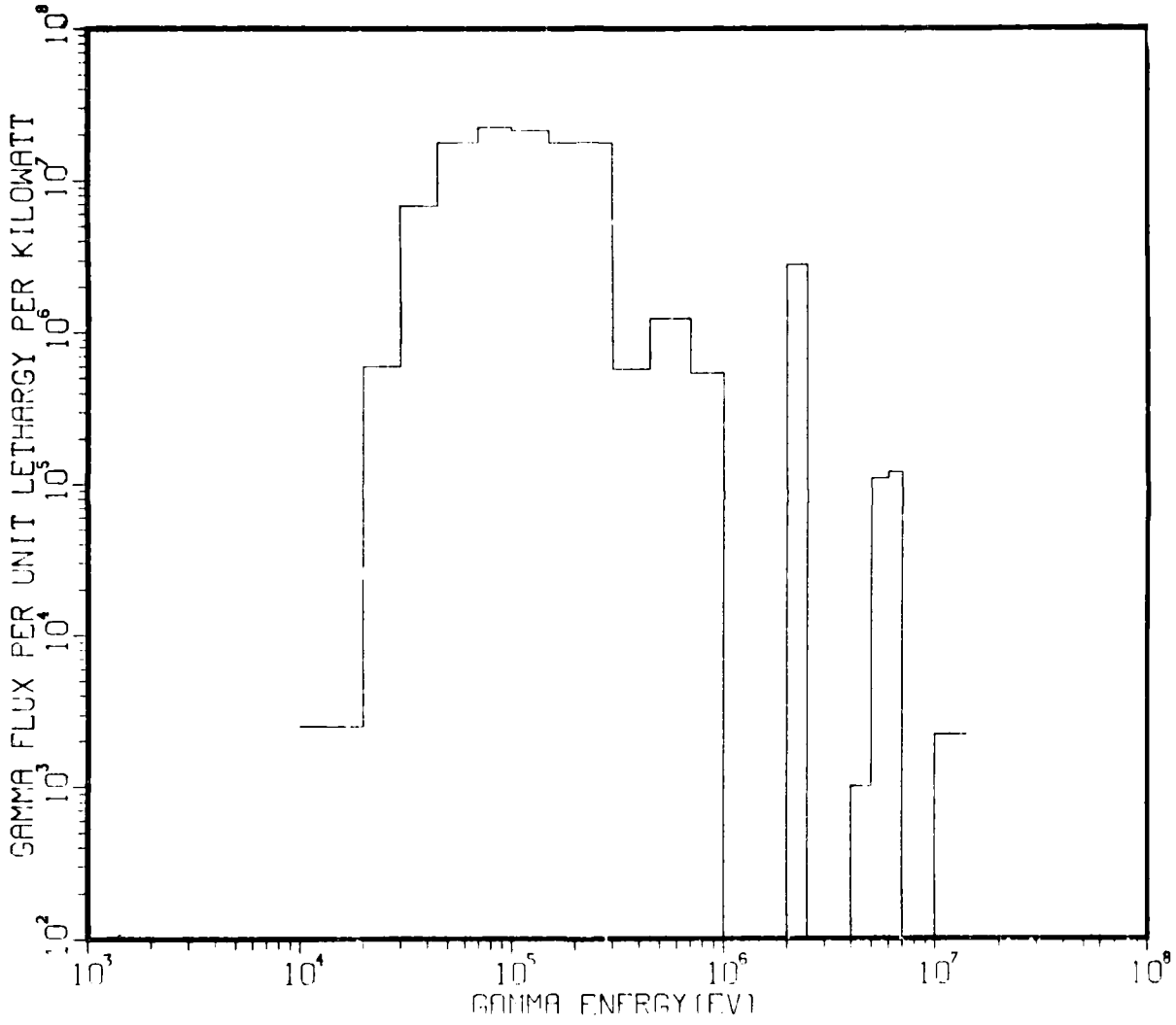

Figure II.3.28. Back Gamma Flux vs Energy ER2 Free Field.

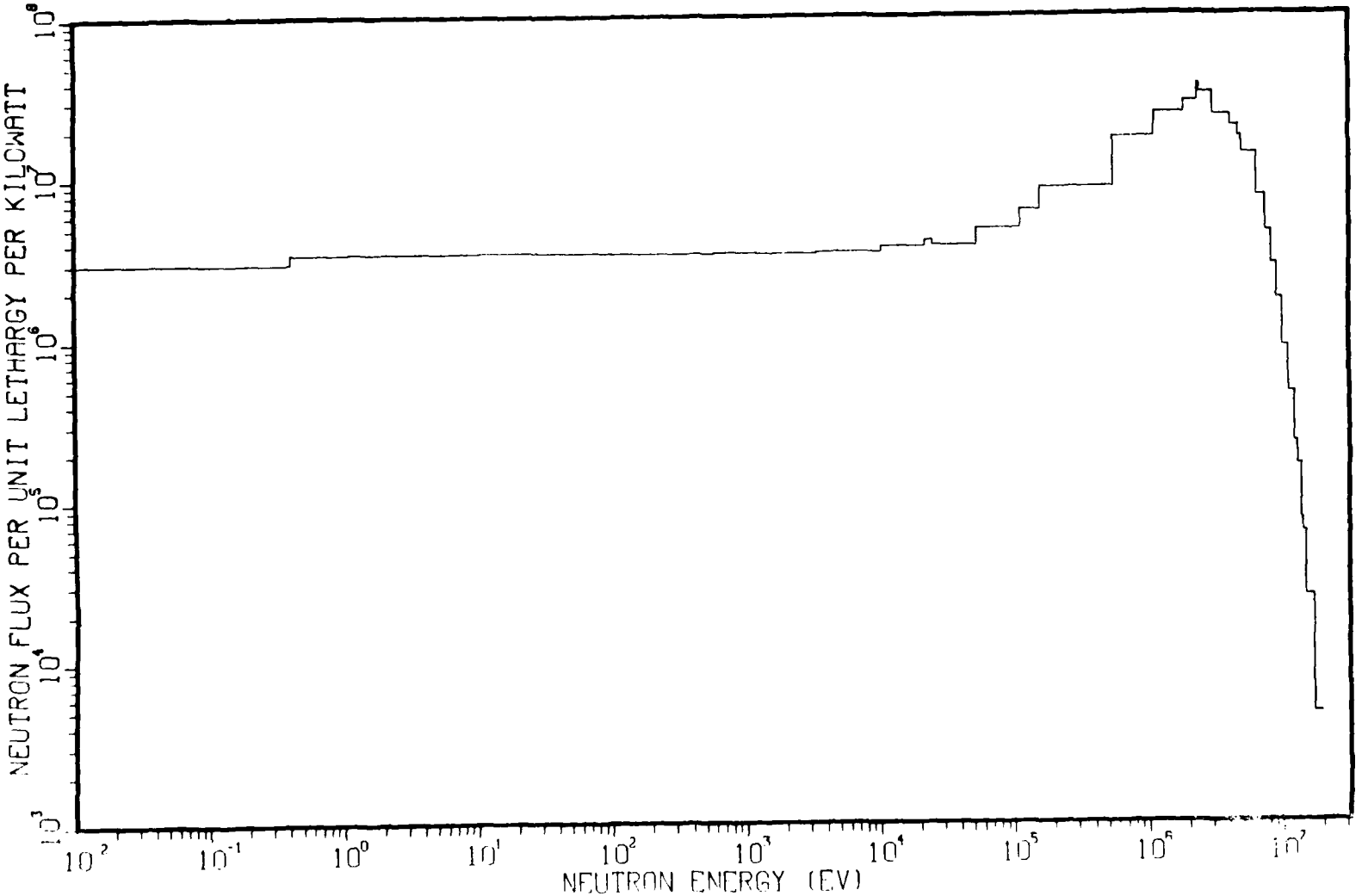

Figure II.3.29. Total (Front+Back, 1-D) Neutron Flux vs Energy ER2 Free Field.

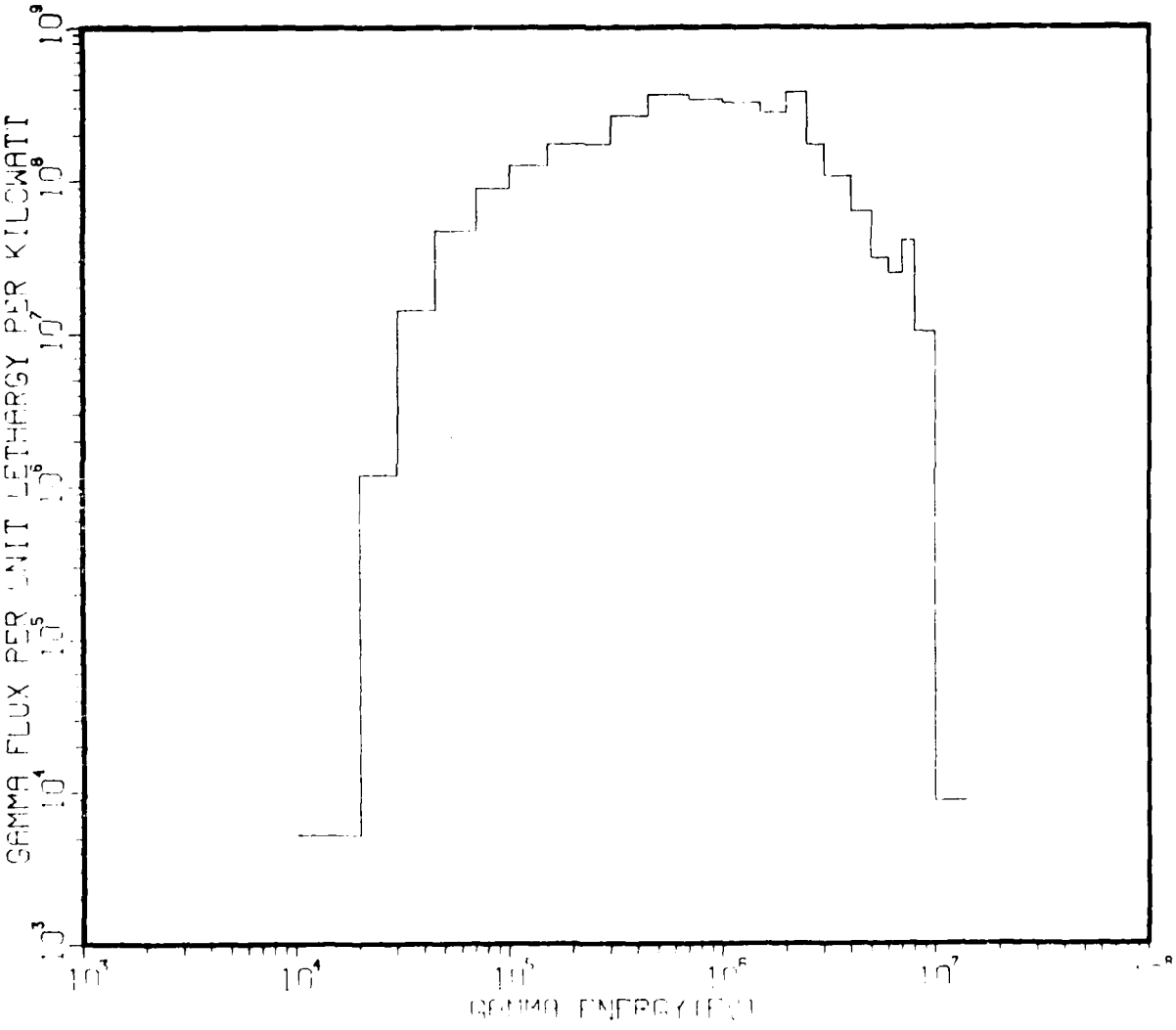

Figure II.3.30. Total (Front+Back) Gamma Flux vs Energy ER2 Free Field.

Table II.3.19. Neutron Flux Per Unit Lethargy Per Kilowatt.

ER2 FREE FIELD

GROUP	ENERGY (EV)	FRONT	BACK	TOTAL
1	1.960E+07	4.71E+03	0.00E+00	4.71E+03
2	1.690E+07	2.51E+04	0.00E+00	2.51E+04
3	1.490E+07	6.19E+04	0.00E+00	6.19E+04
4	1.420E+07	7.45E+04	0.00E+00	7.45E+04
5	1.380E+07	1.63E+05	0.00E+00	1.63E+05
6	1.280E+07	2.26E+05	0.00E+00	2.26E+05
7	1.220E+07	4.62E+05	0.00E+00	4.62E+05
8	1.110E+07	8.93E+05	0.00E+00	8.93E+05
9	1.000E+07	1.73E+06	0.00E+00	1.73E+06
10	9.050E+06	2.85E+06	0.00E+00	2.85E+06
11	8.190E+06	4.56E+06	0.00E+00	4.56E+06
12	7.410E+06	7.53E+06	0.00E+00	7.53E+06
13	6.380E+06	1.36E+07	3.71E+02	1.36E+07
14	4.970E+06	1.73E+07	7.51E+03	1.74E+07
15	4.720E+06	2.02E+07	2.74E+04	2.02E+07
16	4.070E+06	2.34E+07	9.56E+04	2.35E+07
17	3.010E+06	3.18E+07	4.73E+05	3.23E+07
18	2.390E+06	3.60E+07	4.17E+05	3.64E+07
19	2.310E+06	2.81E+07	4.04E+05	2.85E+07
20	1.830E+06	2.39E+07	4.08E+05	2.43E+07
21	1.110E+06	1.68E+07	4.80E+05	1.73E+07
22	5.500E+05	8.24E+06	3.49E+05	8.59E+06
23	1.580E+05	5.93E+06	3.00E+05	6.23E+06
24	1.110E+05	4.58E+06	2.55E+05	4.83E+06
25	5.250E+04	3.56E+06	2.33E+05	3.79E+06
26	2.480E+04	3.86E+06	2.29E+05	4.09E+06
27	2.190E+04	3.54E+06	2.32E+05	3.78E+06
28	1.030E+04	3.28E+06	2.43E+05	3.52E+06
29	3.350E+03	3.19E+06	2.55E+05	3.45E+06
30	1.230E+03	3.18E+06	2.69E+05	3.45E+06
31	5.830E+02	3.16E+06	2.88E+05	3.44E+06
32	1.010E+02	3.16E+06	3.06E+05	3.47E+06
33	2.900E+01	3.17E+06	3.18E+05	3.49E+06
34	1.070E+01	3.14E+06	3.29E+05	3.47E+06
35	3.060E+00	3.14E+06	3.38E+05	3.48E+06
36	1.130E+00	3.09E+06	3.42E+05	3.43E+06
37	4.140E-01	2.84E+06	1.60E+05	3.00E+06

Table II.3.20. Gamma Flux Per Unit Lethargy Per Kilowatt.

ER2 FREE FIELD

GROUP	ENERGY (EV)	FRONT	BACK	TOTAL
1	1.400E+07	6.48E+03	2.18E+03	8.66E+03
2	1.000E+07	1.03E+07	0.00E+00	1.03E+07
3	8.000E+06	4.00E+07	0.00E+00	4.00E+07
4	7.000E+06	2.46E+07	1.19E+05	2.47E+07
5	6.000E+06	3.10E+07	1.08E+05	3.11E+07
6	5.000E+06	6.28E+07	1.00E+03	6.28E+07
7	4.000E+06	1.07E+08	0.00E+00	1.07E+08
8	3.000E+06	1.70E+08	0.00E-00	1.70E+08
9	2.500E+06	3.70E+08	2.79E+06	3.73E+08
10	2.000E+06	2.76E+08	0.00E+00	2.76E+08
11	1.500E+06	3.20E+08	0.00E+00	3.20E+08
12	1.000E+06	3.34E+08	5.38E+05	3.35E+08
13	7.000E+05	3.58E+08	1.22E+06	3.60E+08
14	4.500E+05	2.62E+08	5.70E+05	2.63E+08
15	3.000E+05	1.55E+08	1.76E+07	1.73E+08
16	1.500E+05	1.04E+08	2.13E+07	1.25E+08
17	1.000E+05	6.56E+07	2.24E+07	8.80E+07
18	7.000E+04	2.88E+07	1.76E+07	4.64E+07
19	4.500E+04	7.40E+06	6.82E+06	1.42E+07
20	3.000E+04	5.93E+05	5.98E+05	1.19E+06
21	2.000E+04	2.68E+03	2.53E+03	5.21E+03

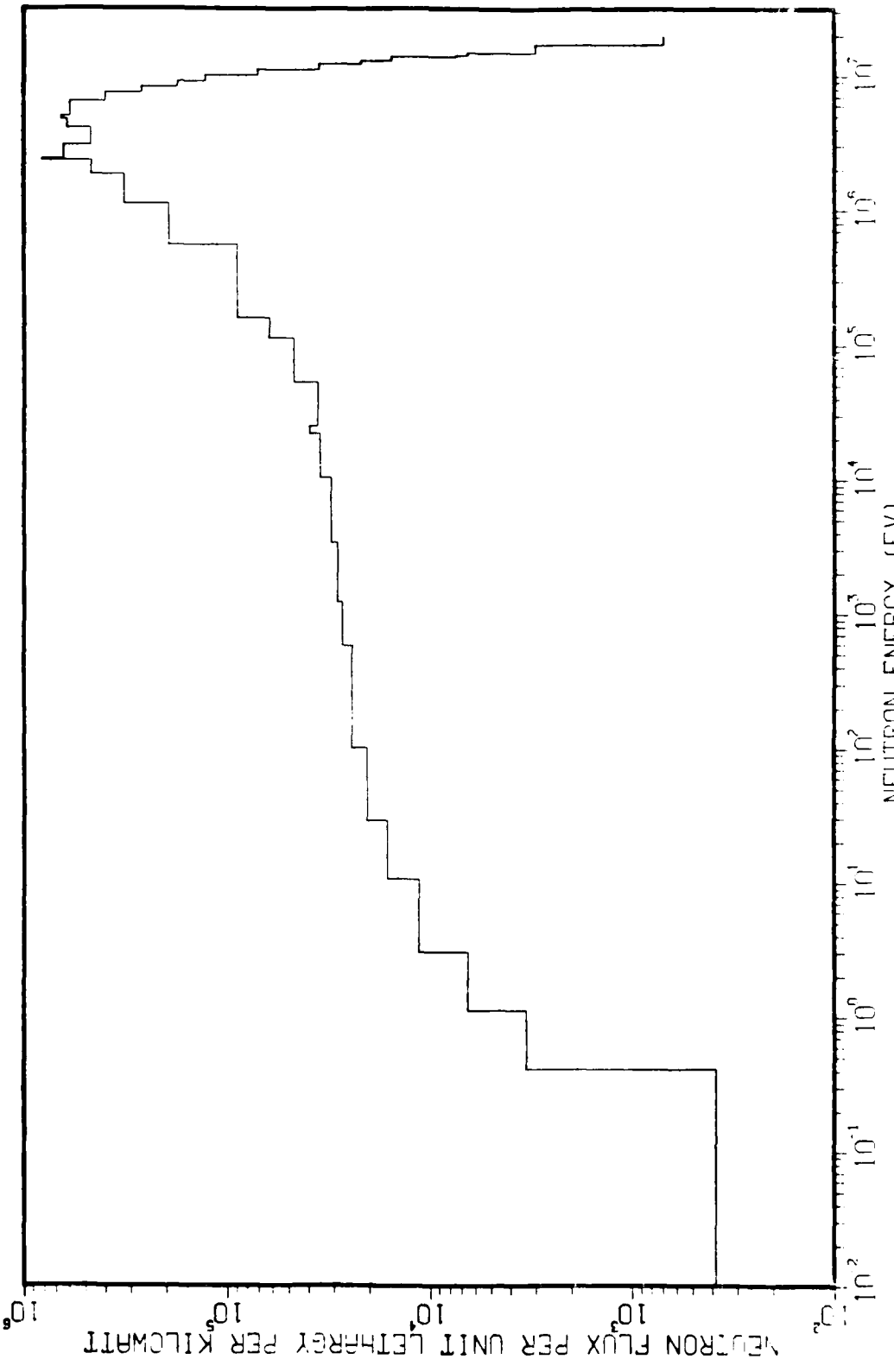

Figure II.3.31. Front (1-D) Neutron Flux vs Energy ER1 Free Field With 12" Water.

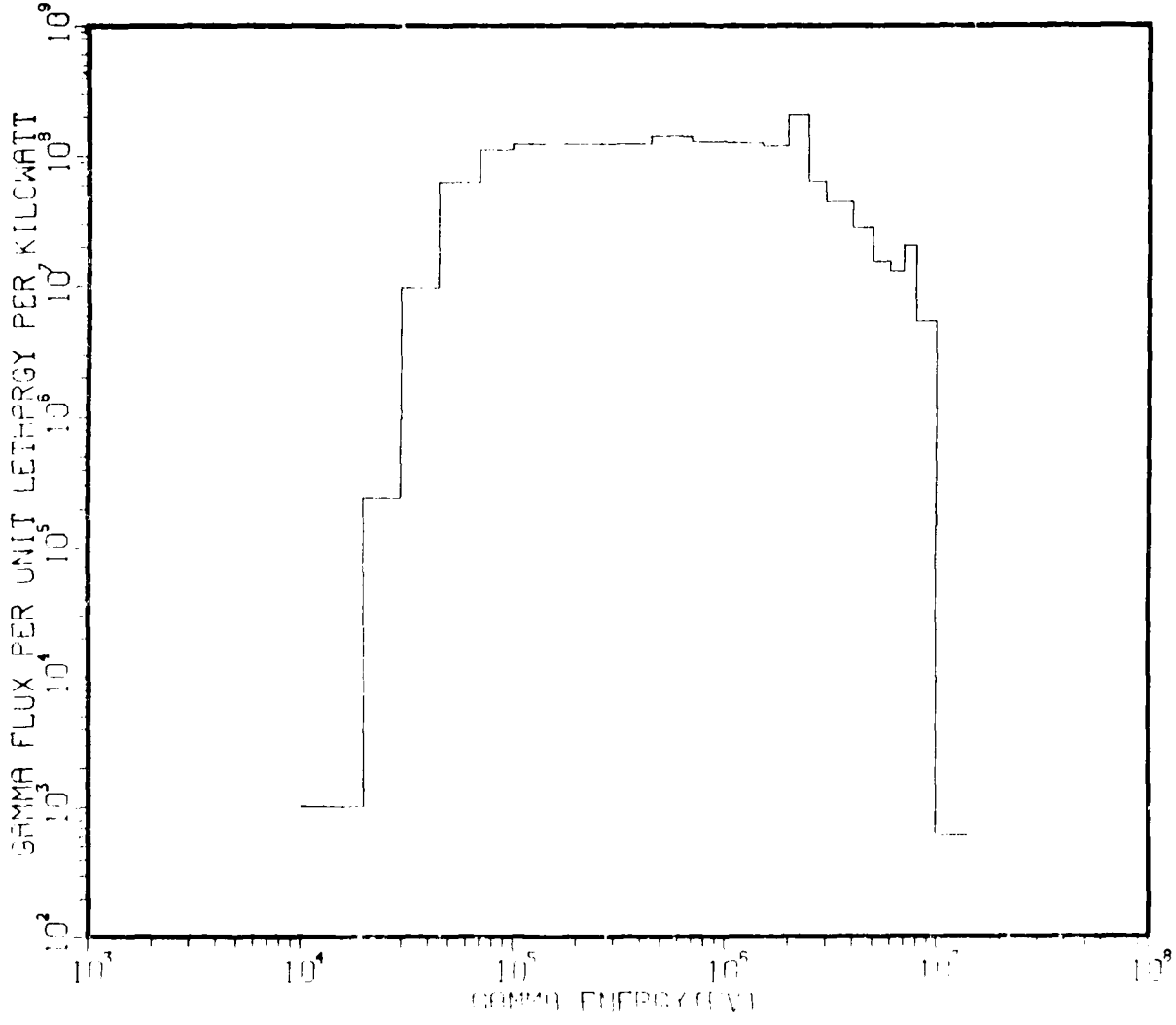

Figure II.3.32. Front Gamma Flux vs Energy ER1 Free Field With 12" Water.

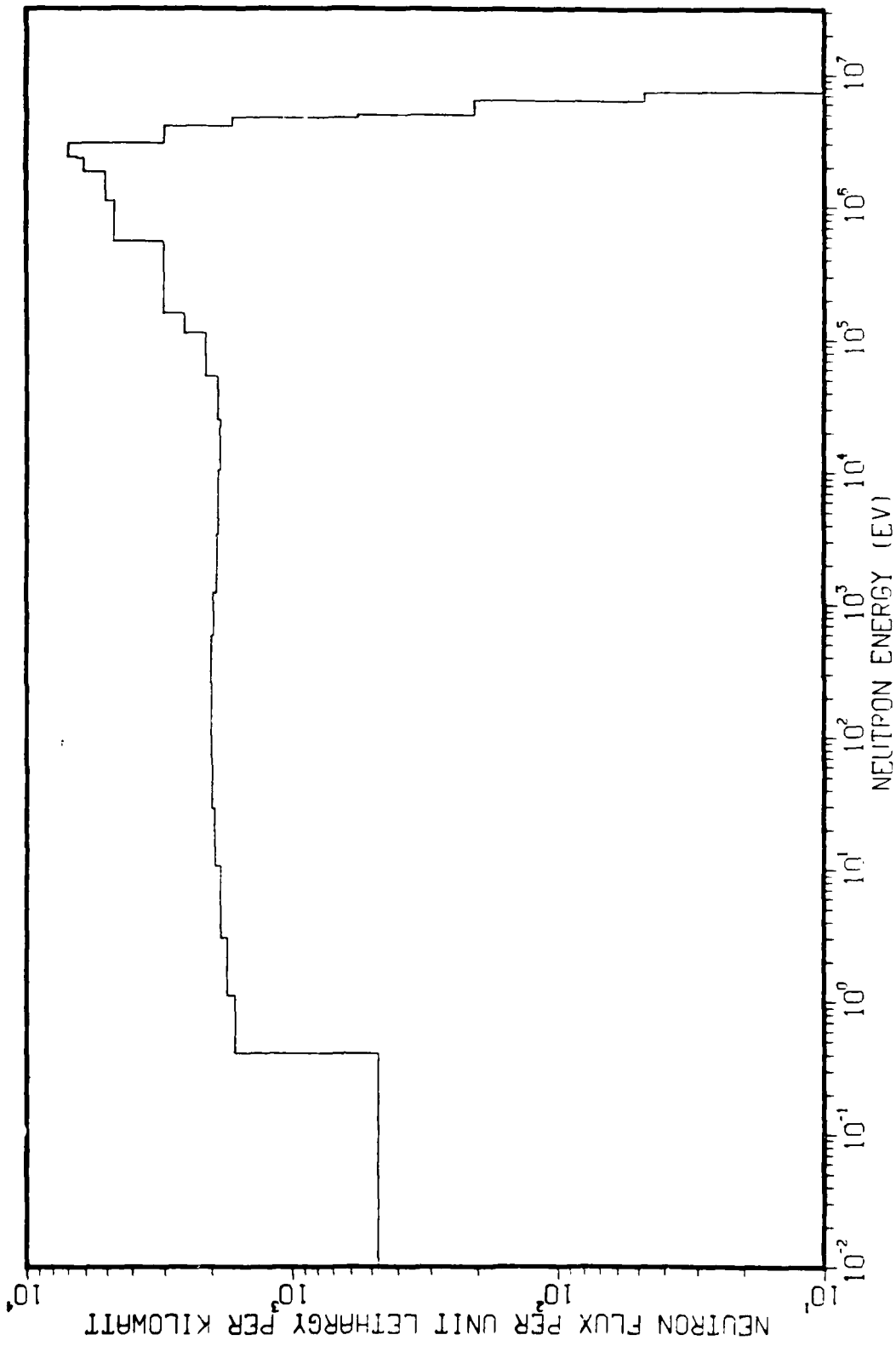

Figure II.3.33. Back (1-D) Neutron Flux vs Energy ERI Free Field With 12" Water.

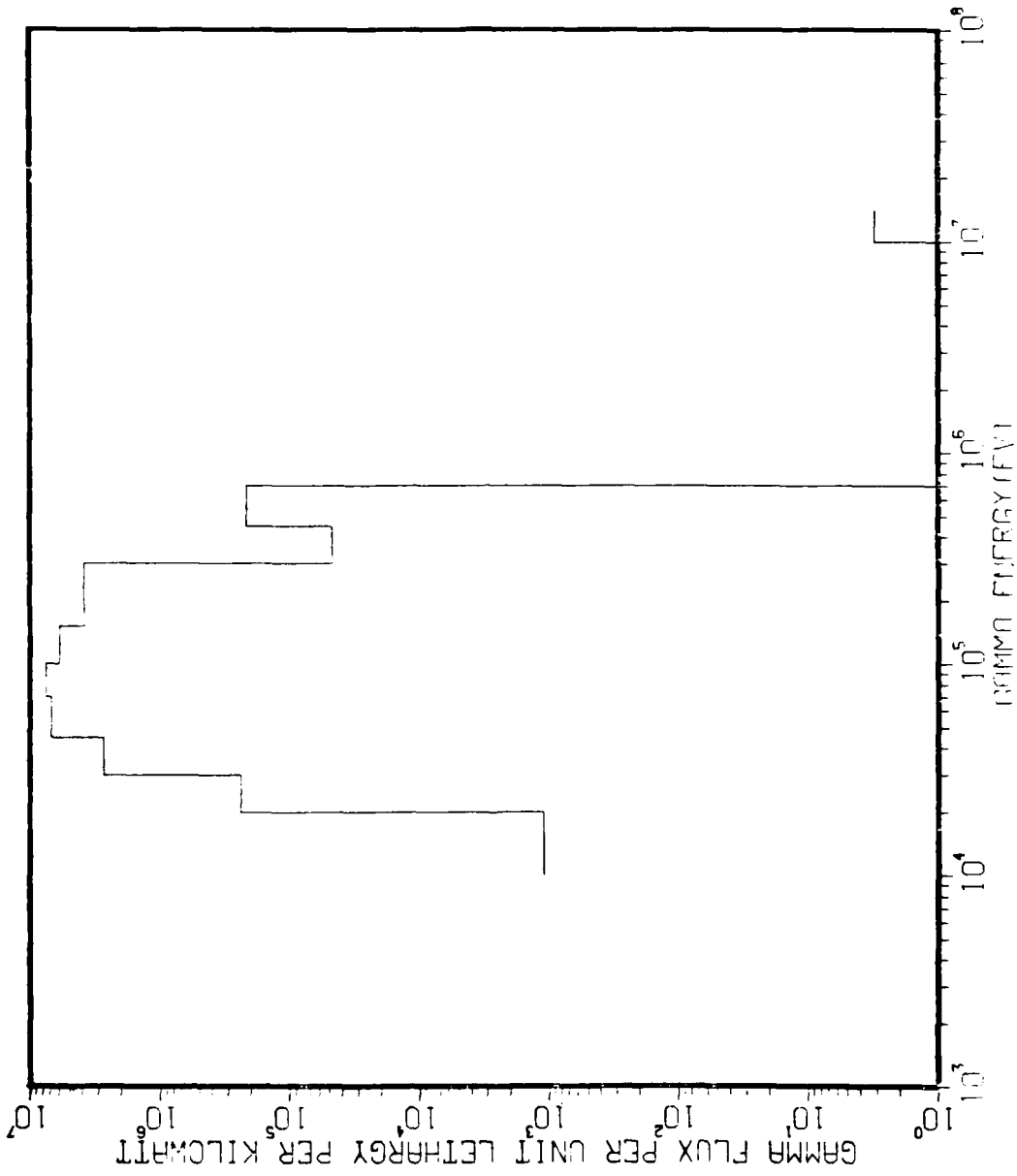

Figure II.3.34. Back Gamma Flux vs Energy ERI Free Field With 12" Water.

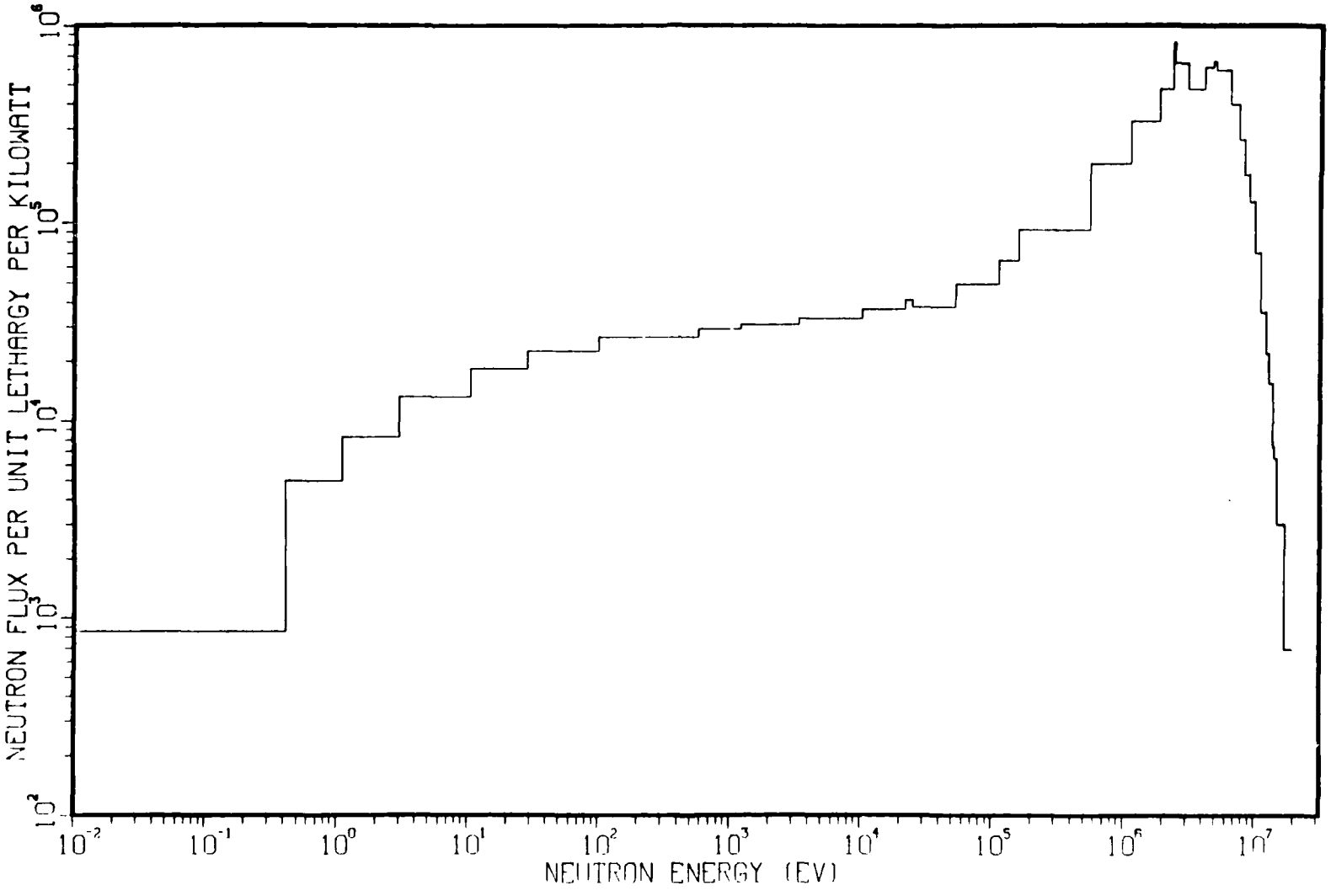

Figure II.3.35. Total (Front+Back, 1-D) Neutron Flux vs Energy ER1 Free Field With 12" Water.

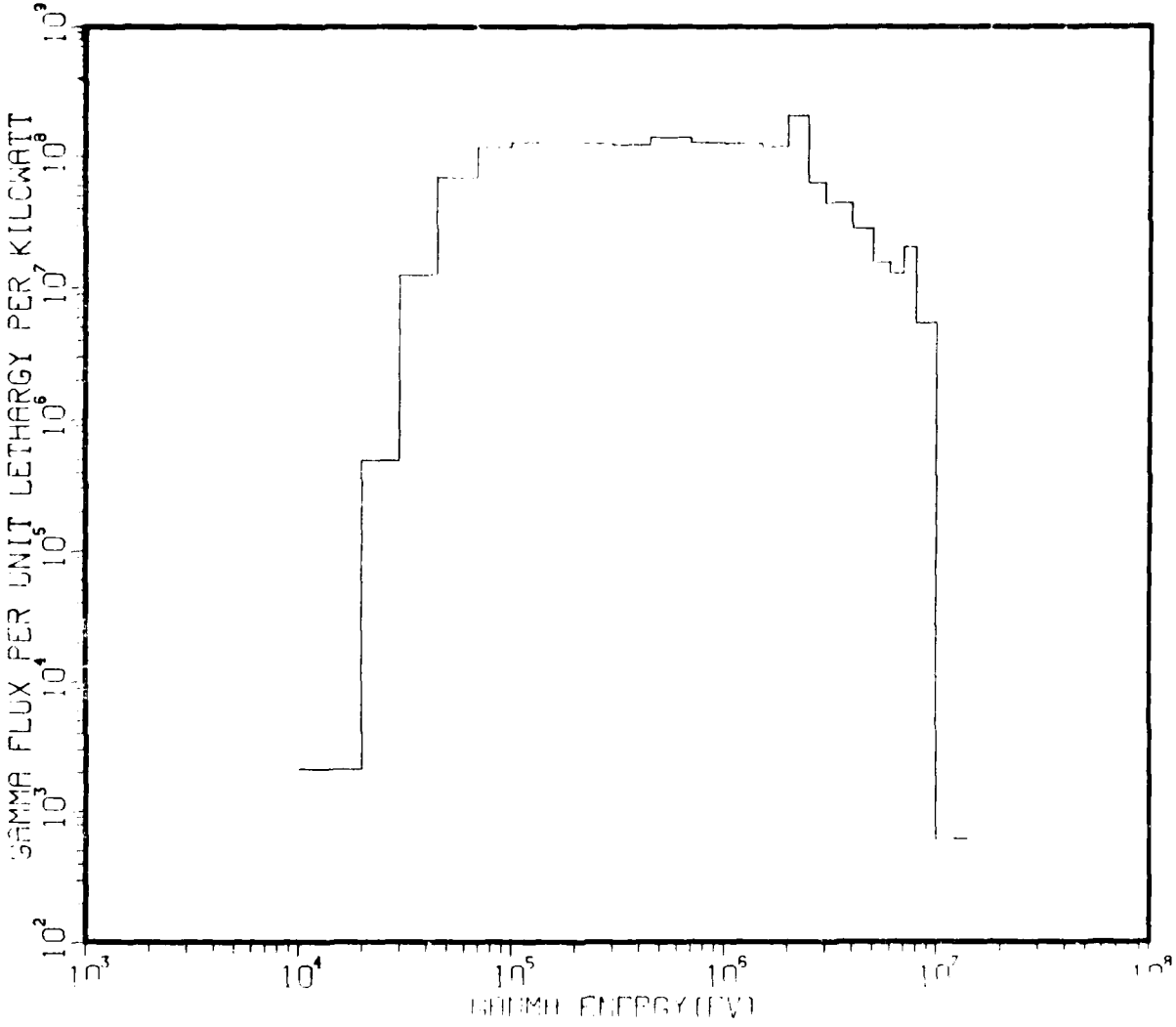

Figure II.3.36. Total (Front+Back) Gamma Flux vs Energy ER1 Free Field With 12" Water.

Table II.3.21. Neutron Flux Per Unit Lethargy Per Kilowatt.

ER1 FREE FIELD WITH 12 IN. WATER

GROUP	ENERGY (EV)	FRONT	BACK	TOTAL
1	1.960E+07	6.97E+02	0.00E+00	6.97E+02
2	1.690E+07	3.03E+03	0.00E+00	3.03E+03
3	1.490E+07	6.56E+03	0.00E+00	6.56E+03
4	1.420E+07	7.46E+03	0.00E+00	7.46E+03
5	1.380E+07	1.57E+04	0.00E+00	1.57E+04
6	1.280E+07	2.22E+04	0.00E+00	2.22E+04
7	1.220E+07	3.59E+04	0.00E+00	3.59E+04
8	1.110E+07	7.12E+04	0.00E+00	7.12E+04
9	1.000E+07	1.29E+05	0.00E+00	1.29E+05
10	9.050E+06	1.77E+05	0.00E+00	1.77E+05
11	8.190E+06	2.65E+05	0.00E+00	2.65E+05
12	7.410E+06	3.99E+05	4.74E+01	3.99E+05
13	6.380E+06	5.91E+05	2.04E+02	5.91E+05
14	4.970E+06	6.55E+05	5.62E+02	6.55E+05
15	4.720E+06	6.11E+05	1.67E+03	6.13E+05
16	4.070E+06	4.71E+05	3.01E+03	4.74E+05
17	3.010E+06	6.38E+05	6.97E+03	6.45E+05
18	2.390E+06	8.11E+05	6.41E+03	8.17E+05
19	2.310E+06	4.68E+05	6.07E+03	4.74E+05
20	1.830E+06	3.21E+05	5.06E+03	3.27E+05
21	1.110E+06	1.96E+05	4.66E+03	2.00E+05
22	5.500E+05	9.02E+04	3.02E+03	9.32E+04
23	1.580E+05	6.27E+04	2.53E+03	6.52E+04
24	1.110E+05	4.76E+04	2.10E+03	4.97E+04
25	5.250E+04	3.62E+04	1.89E+03	3.81E+04
26	2.480E+04	3.96E+04	1.85E+03	4.15E+04
27	2.190E+04	3.55E+04	1.86E+03	3.73E+04
28	1.030E+04	3.14E+04	1.89E+03	3.33E+04
29	3.350E+03	2.91E+04	1.92E+03	3.10E+04
30	1.230E+03	2.76E+04	1.97E+03	2.96E+04
31	5.830E+02	2.47E+04	2.01E+03	2.67E+04
32	1.010E+02	2.07E+04	2.00E+03	2.27E+04
33	2.900E+01	1.65E+04	1.96E+03	1.84E+04
34	1.070E+01	1.14E+04	1.86E+03	1.33E+04
35	3.060E+00	6.55E+03	1.75E+03	8.31E+03
36	1.130E+00	3.33E+03	1.65E+03	4.99E+03
37	4.140E-01	3.86E+02	4.73E+02	8.59E+02

Table II.3.22. Gamma Flux Per Unit Lethargy Per Kilowatt.

ER1 FREE FIELD WITH 12 IN. WATER

GROUP	ENERGY (EV)	FRONT	BACK	TOTAL
1	1.400E+07	6.08E+02	3.03E+00	6.11E+02
2	1.000E+07	5.41E+06	0.00E+00	5.41E+06
3	8.000E+06	2.04E+07	0.00E+00	2.04E+07
4	7.000E+06	1.28E+07	0.00E+00	1.28E+07
5	6.000E+06	1.53E+07	0.00E+00	1.53E+07
6	5.000E+06	2.83E+07	0.00E+00	2.83E+07
7	4.000E+06	4.43E+07	0.00E+00	4.43E+07
8	3.000E+06	6.36E+07	0.00E+00	6.36E+07
9	2.500E+06	2.06E+08	0.00E+00	2.06E+08
10	2.000E+06	1.19E+08	0.00E+00	1.19E+08
11	1.500E+06	1.26E+03	0.00E+00	1.26E+08
12	1.000E+06	1.29E+08	0.00E+00	1.29E+08
13	7.000E+05	1.40E+08	2.14E+05	1.40E+08
14	4.500E+05	1.23E+08	4.77E+04	1.23E+08
15	3.000E+05	1.23E+08	3.82E+06	1.27E+08
16	1.500E+05	1.22E+08	5.89E+06	1.26E+08
17	1.000E+05	1.11E+08	7.48E+06	1.18E+08
18	7.000E+04	6.22E+07	6.84E+06	6.91E+07
19	4.500E+04	9.76E+06	2.72E+06	1.25E+07
20	3.000E+04	2.43E+05	2.40E+05	4.83E+05
21	2.000E+04	1.02E+03	1.10E-03	2.12E+03

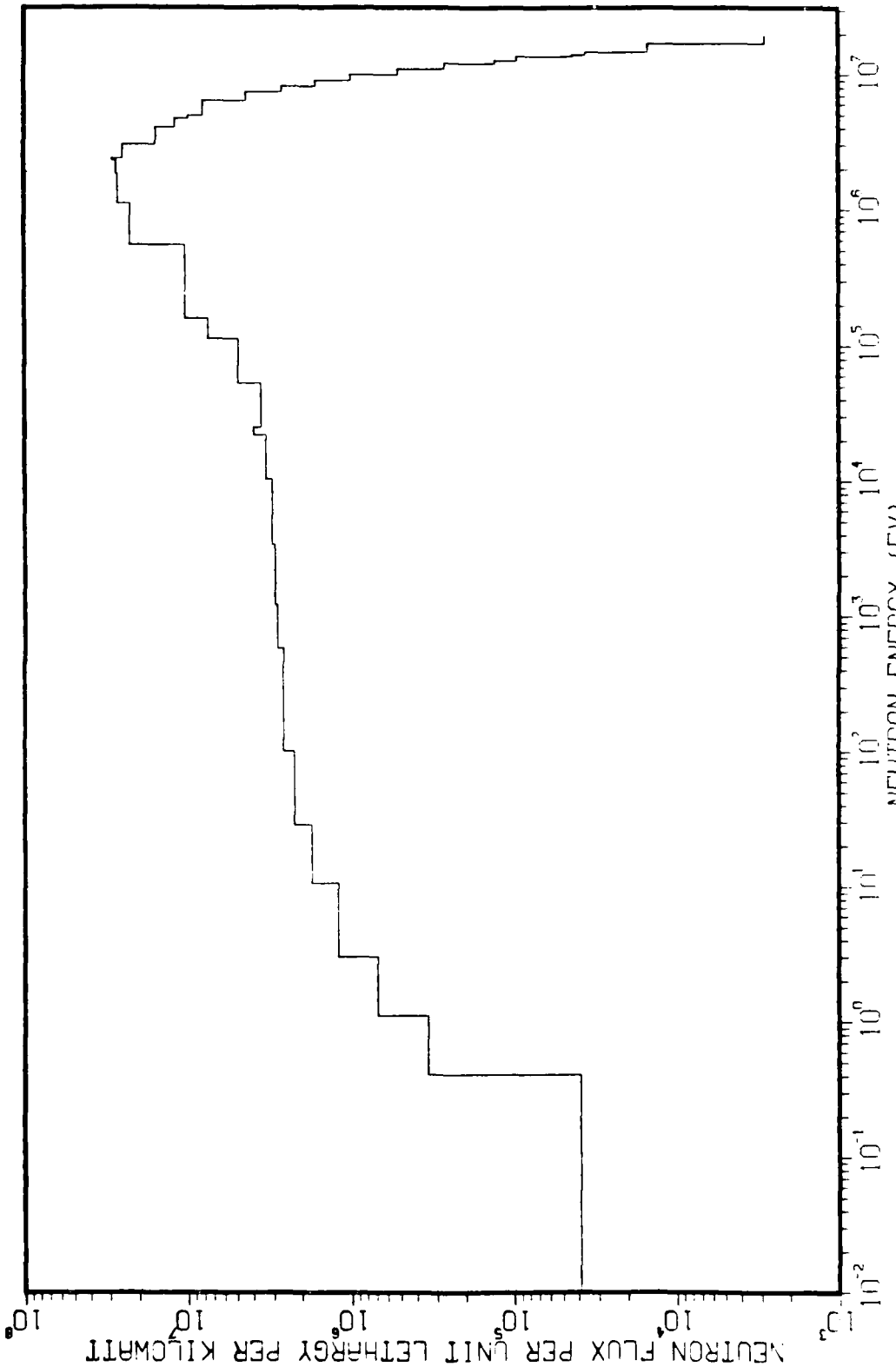

Figure II.3.37. Front (1-D) Neutron Flux vs Energy ER1 With 2" PB.

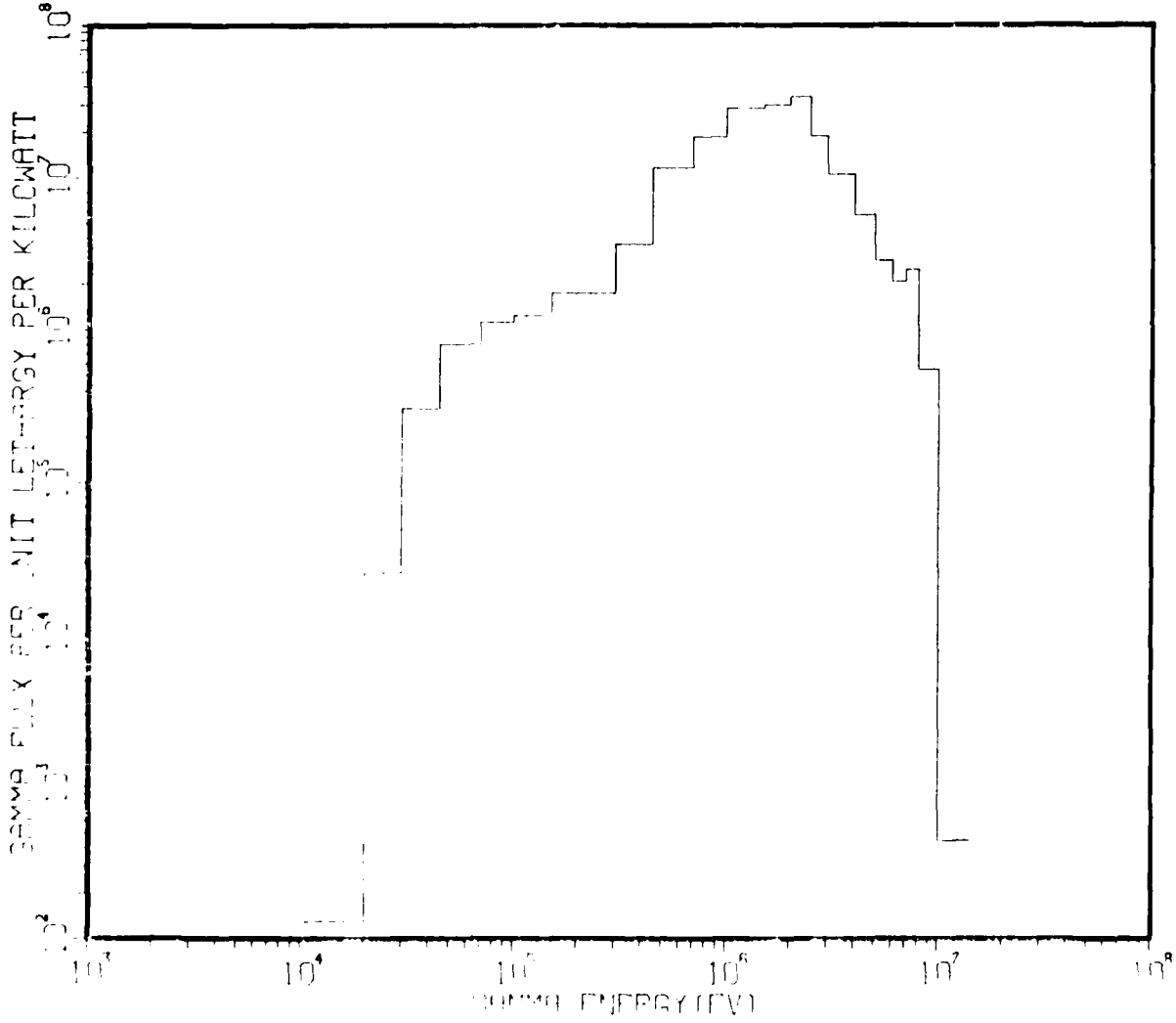

Figure II.3.38. Front Gamma Flux vs Energy ER1 With 2" PB.

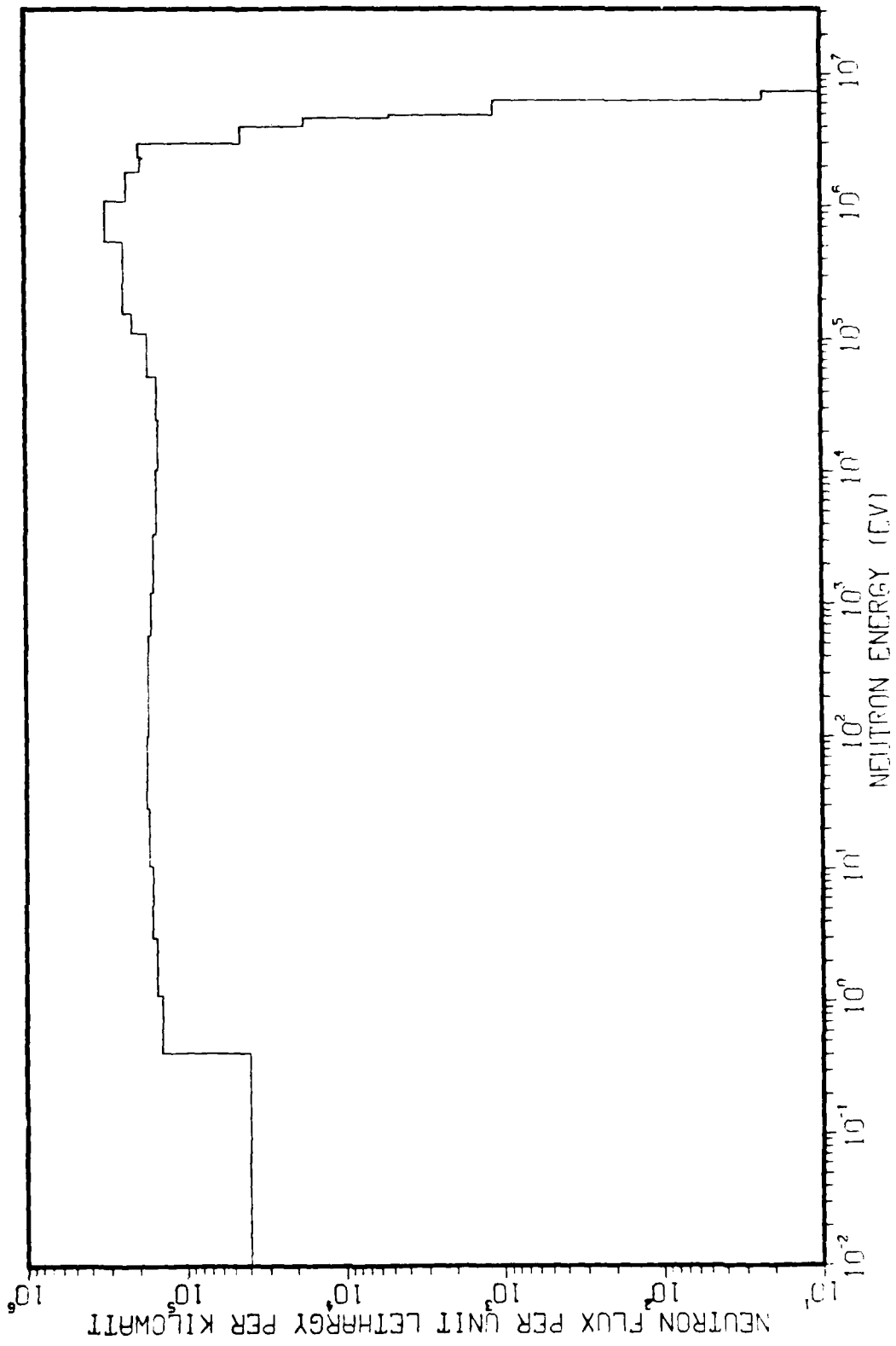

Figure II.3.39. Back (1-D) Neutron Flux vs Energy ER1 With 2" PB.

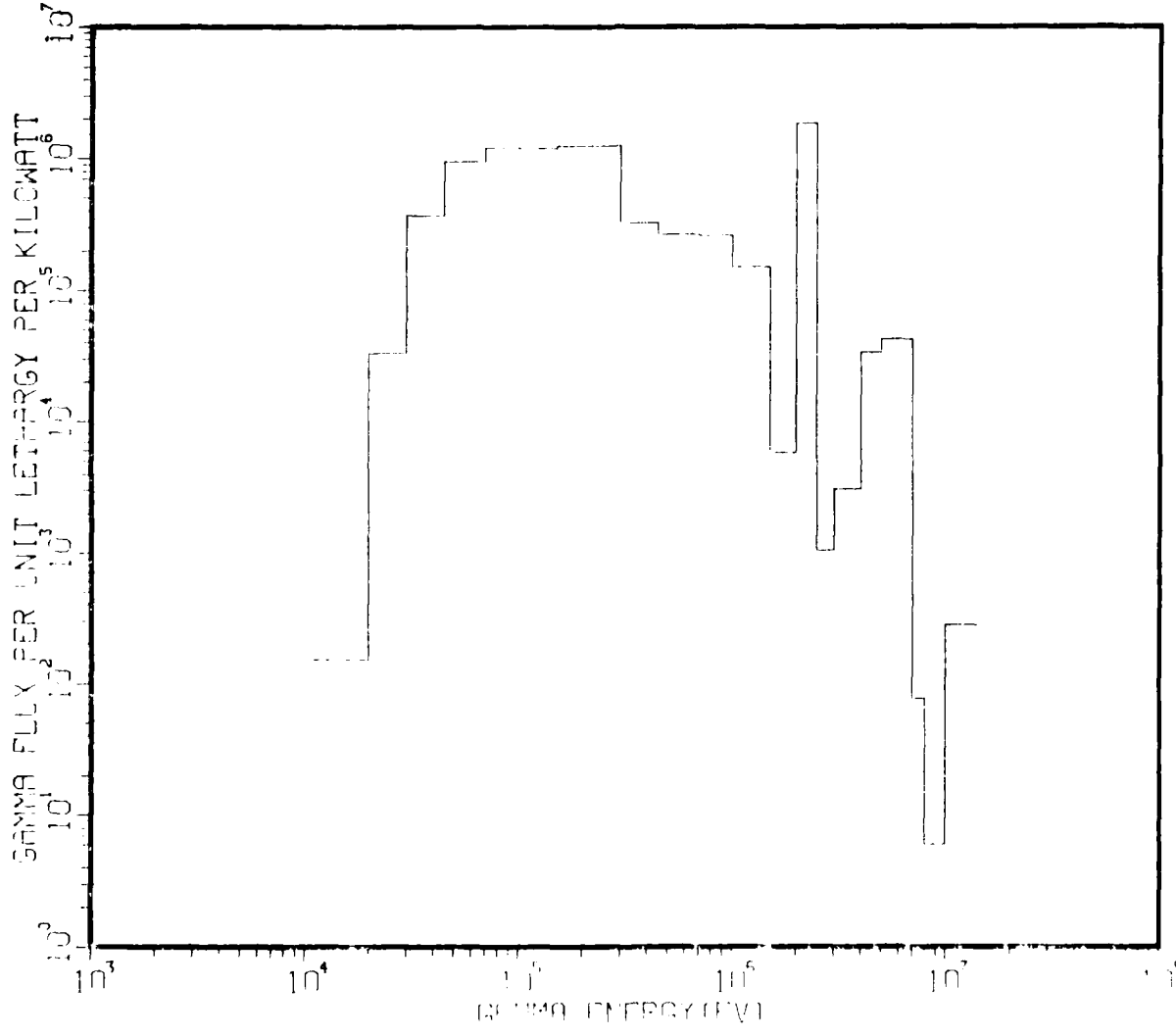

Figure II.3.40. Back Gamma Flux vs Energy ER1 With 2" PB.

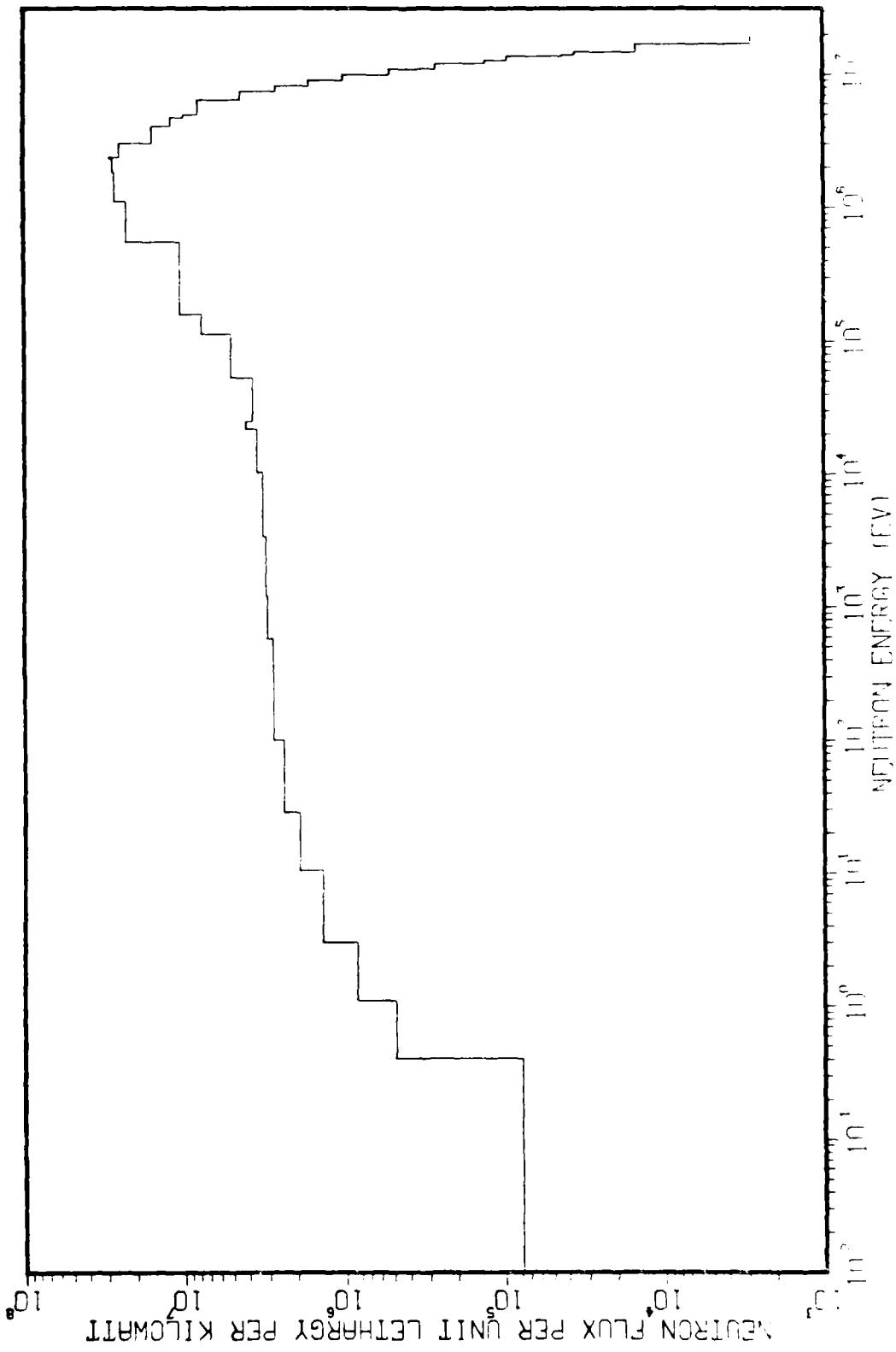

Figure II.3.41. Total (Front+Back, 1-D) Neutron Flux vs Energy ER1 With 2" PB.

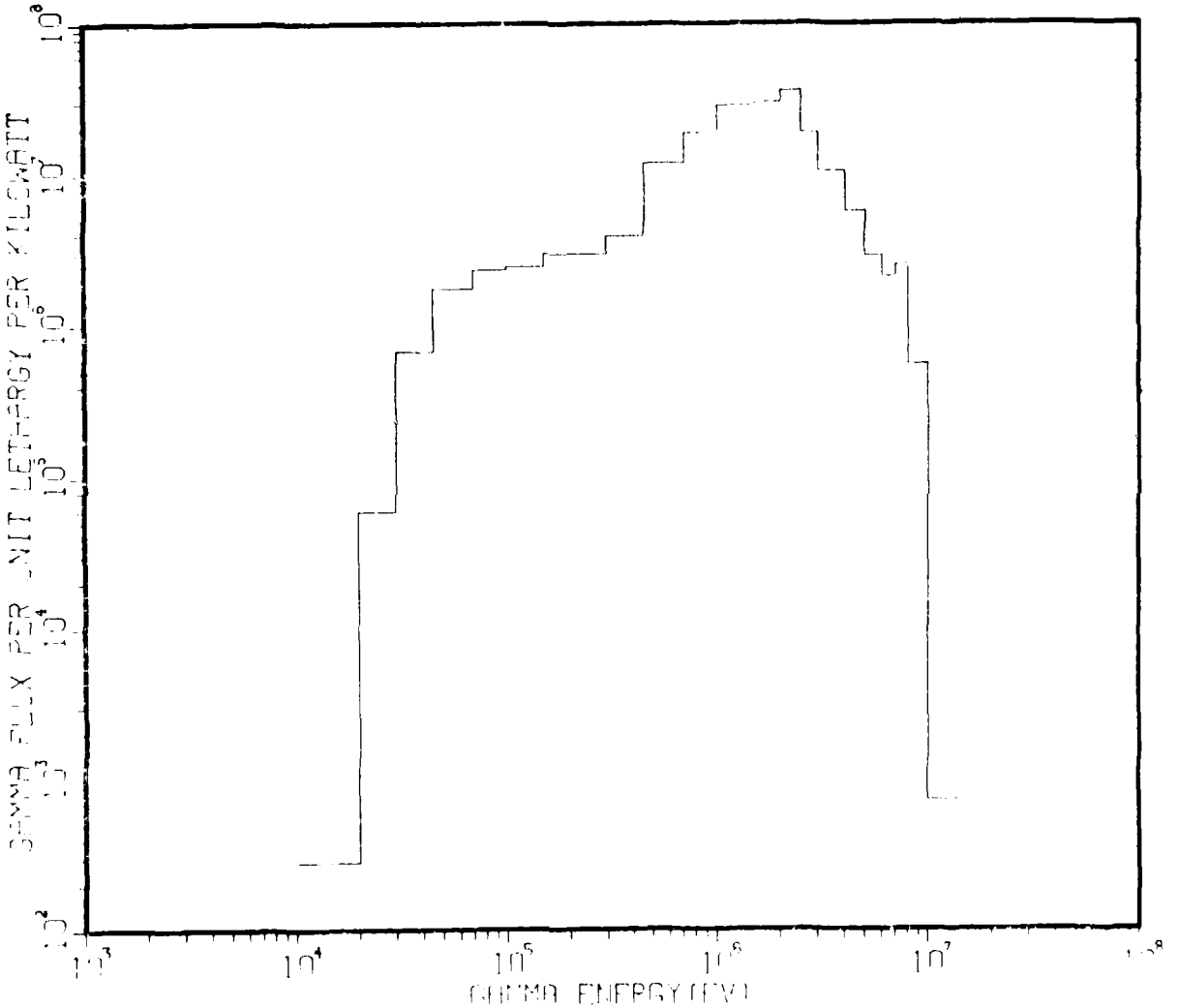

Figure II.3.42. Total (Front+Back) Gamma Flux vs Energy ER1 With 2" PB.

Table II.3.23. Neutron Flux Per Unit Lethargy Per Kilowatt.

		ER1 WITH 2 IN. PB		
GROUP	ENERGY (EV)	FRONT	BACK	TOTAL
1	1.960E+07	2.82E+03	0.00E+00	2.82E+03
2	1.690E+07	1.48E+04	0.00E+00	1.48E+04
3	1.490E+07	3.61E+04	0.00E+00	3.61E+04
4	1.420E+07	4.32E+04	0.00E+00	4.32E+04
5	1.380E+07	9.51E+04	0.00E+00	9.51E+04
6	1.280E+07	1.31E+05	0.00E+00	1.31E+05
7	1.220E+07	2.68E+05	0.00E+00	2.68E+05
8	1.110E+07	5.18E+05	0.00E+00	5.18E+05
9	1.000E+07	1.01E+06	0.00E+00	1.01E+06
10	9.050E+06	1.66E+06	0.00E+00	1.66E+06
11	8.190E+06	2.66E+06	0.00E+00	2.66E+06
12	7.410E+06	4.42E+06	2.32E+01	4.42E+06
13	6.380E+06	8.05E+06	1.12E+03	8.05E+06
14	4.970E+06	9.95E+06	5.05E+03	9.96E+06
15	4.720E+06	1.19E+07	1.76E+04	1.19E+07
16	4.070E+06	1.55E+07	4.39E+04	1.55E+07
17	3.010E+06	2.48E+07	1.94E+05	2.50E+07
18	2.390E+06	2.86E+07	1.82E+05	2.87E+07
19	2.310E+06	2.72E+07	1.87E+05	2.74E+07
20	1.830E+06	2.67E+07	2.30E+05	2.69E+07
21	1.110E+06	2.24E+07	3.15E+05	2.27E+07
22	5.500E+05	1.03E+07	2.43E+05	1.05E+07
23	1.583E+05	7.51E+06	2.14E+05	7.72E+06
24	1.110E+05	4.91E+06	1.73E+05	5.08E+06
25	5.250E+04	3.57E+06	1.52E+05	3.72E+06
26	2.480E+04	3.95E+06	1.47E+05	4.10E+06
27	2.190E+04	3.34E+06	1.49E+05	3.49E+06
28	1.030E+04	3.07E+06	1.53E+05	3.22E+06
29	3.350E+03	2.93E+06	1.60E+05	3.09E+06
30	1.230E+03	2.86E+06	1.67E+05	3.03E+06
31	5.830E+02	2.61E+06	1.72E+05	2.79E+06
32	1.010E+02	2.24E+06	1.76E+05	2.42E+06
33	2.900E+01	1.76E+06	1.71E+05	1.93E+06
34	1.070E+01	1.22E+06	1.63E+05	1.38E+06
35	3.060E+00	6.94E+05	1.52E+05	8.46E+05
36	1.130E+00	3.43E+05	1.42E+05	4.85E+05
37	4.140E-01	3.89E+04	3.96E+04	7.84E+04

Table II.3.24. Gamma Flux Per Unit Lethargy Per Kilowatt.

ER1 WITH 2 IN. PB

GROUP	ENERGY (EV)	FRONT	BACK	TOTAL
1	1.400E+07	4.44E+02	2.78E+02	7.22E+02
2	1.000E+07	5.45E+05	5.96E+00	5.45E+05
3	8.000E+06	2.48E+06	7.79E+01	2.48E+06
4	7.000E+06	2.05E+06	4.21E+04	2.09E+06
5	6.000E+06	2.82E+06	4.23E+04	2.86E+06
6	5.000E+06	5.66E+06	3.33E+04	5.69E+06
7	4.000E+06	1.05E+07	3.04E+03	1.05E+07
8	3.000E+06	1.88E+07	1.04E+03	1.88E+07
9	2.500E+06	3.39E+07	1.83E+06	3.58E+07
10	2.000E+06	3.01E+07	5.74E+03	3.02E+07
11	1.500E+06	2.86E+07	1.52E+05	2.88E+07
12	1.000E+06	1.85E+07	2.64E+05	1.88E+07
13	7.000E+05	1.16E+07	2.68E+05	1.18E+07
14	4.500E+05	3.61E+06	3.24E+05	3.94E+06
15	3.000E+05	1.73E+06	1.26E+06	2.99E+06
16	1.500E+05	1.24E+06	1.20E+06	2.44E+06
17	1.000E+05	1.12E+06	1.21E+06	2.33E+06
18	7.000E+04	8.01E+05	9.54E+05	1.75E+06
19	4.500E+04	3.06E+05	3.74E-05	6.79E+05
20	3.000E+04	2.61E+04	3.30E+04	5.90E+04
21	2.000E+04	1.29E+02	1.53E+02	2.82E+02

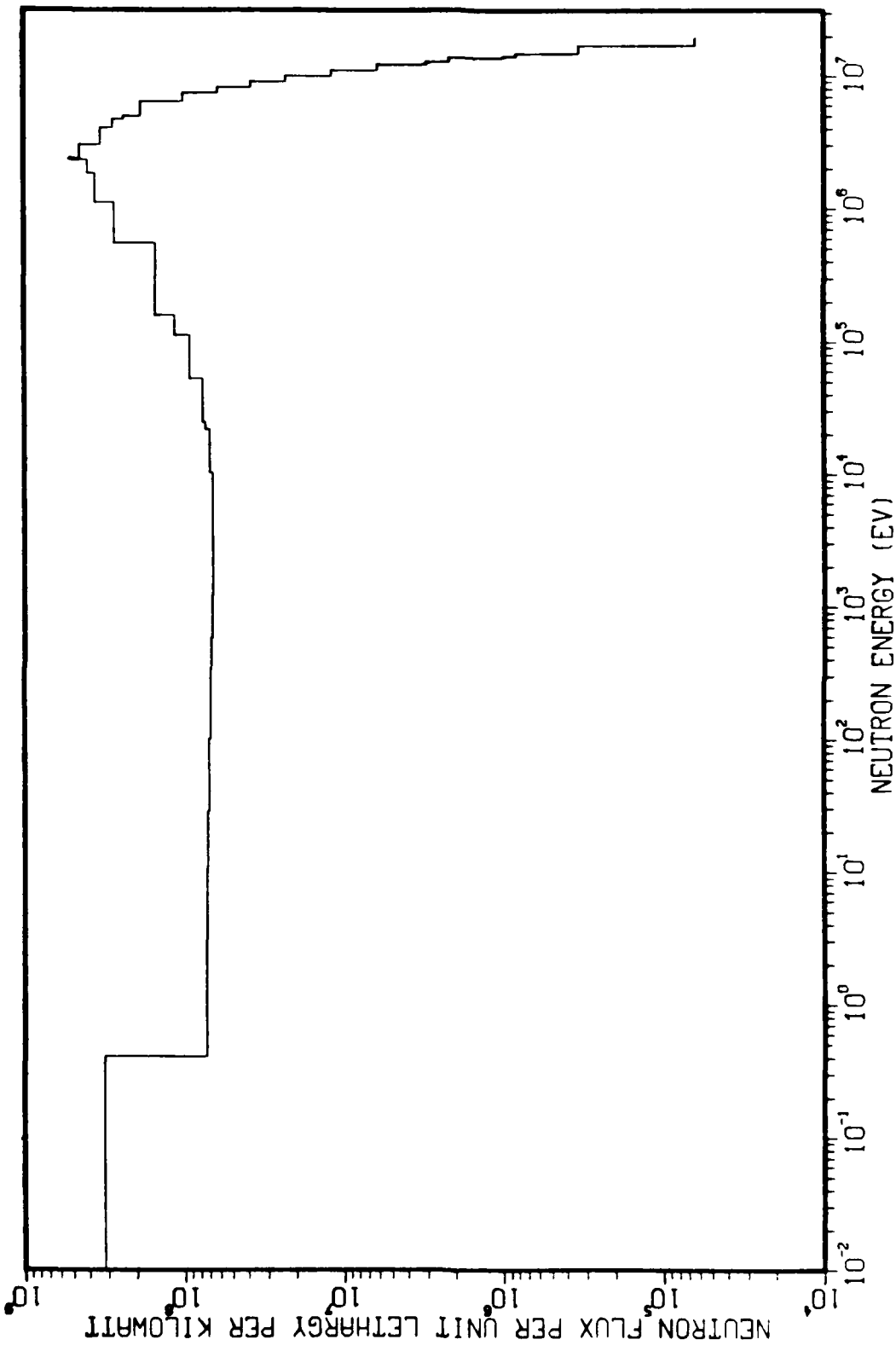

Figure II.3.43. Front (1-D) Neutron Flux vs Energy at Center of Pneumatic Tubes.

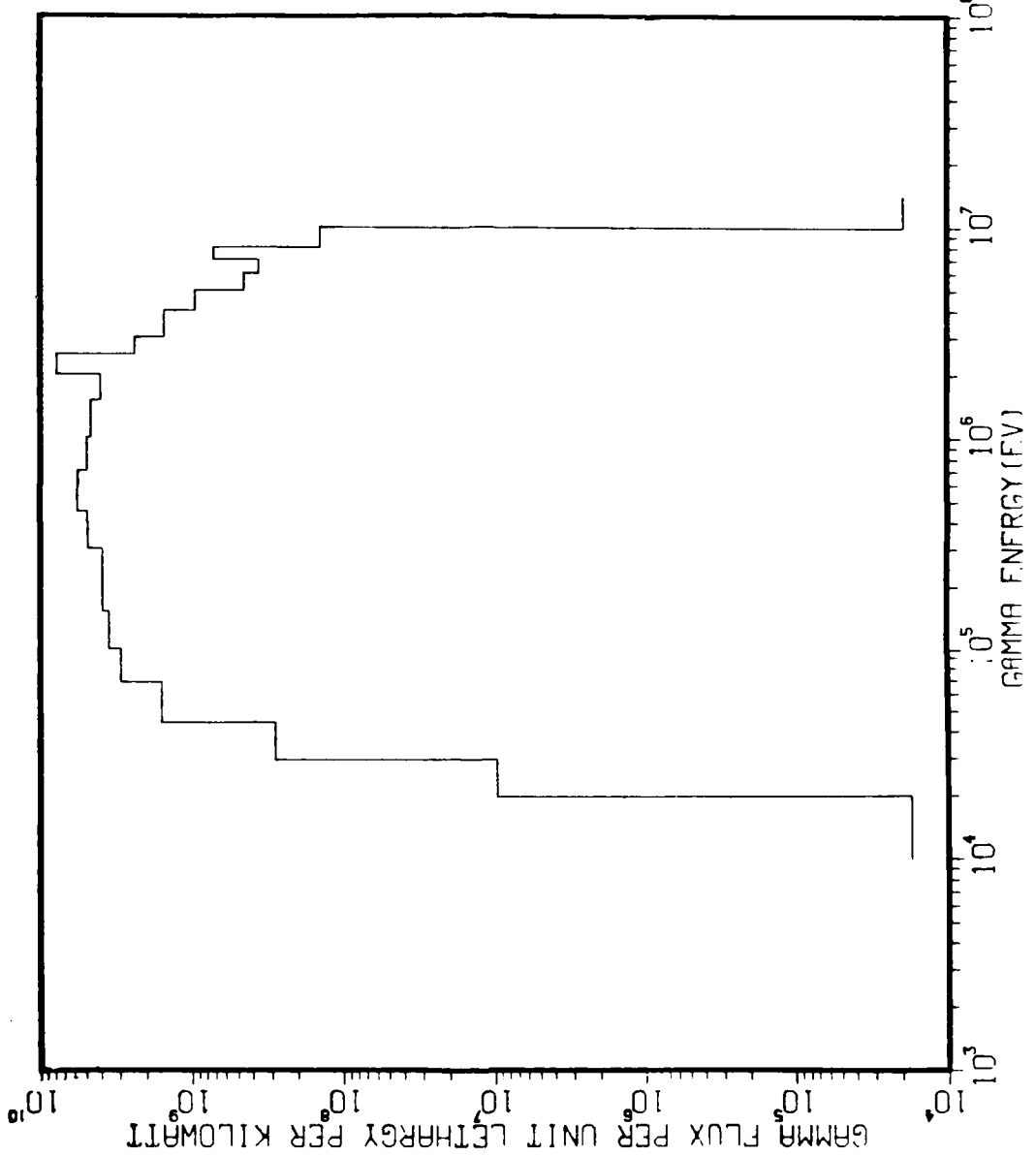

Figure II.3.44. Front Gamma Flux vs Energy at Center of Pneumatic Tubes.

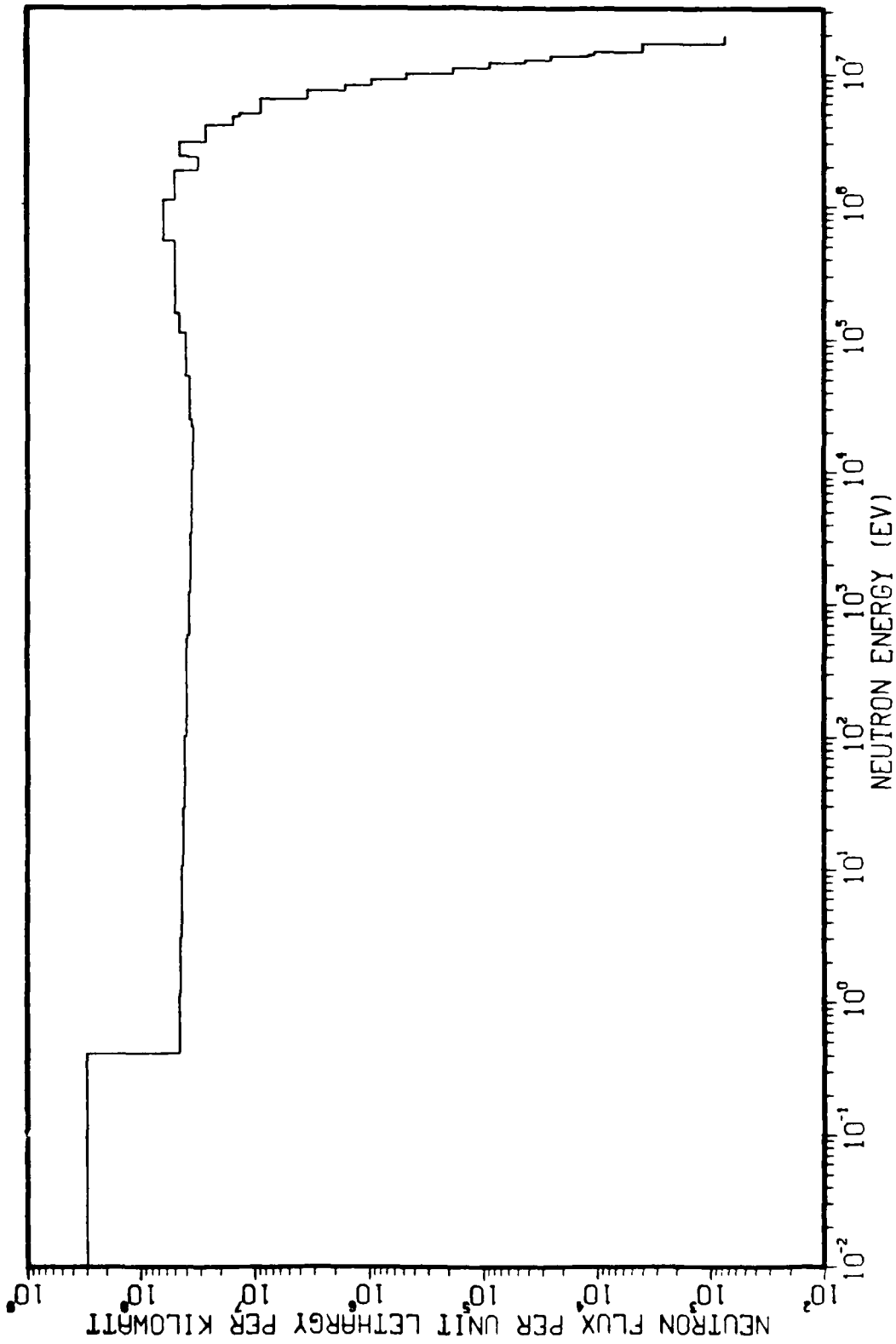

Figure II.3.45. Back (1-D) Neutron Flux vs Energy at Center of Pneumatic Tubes.

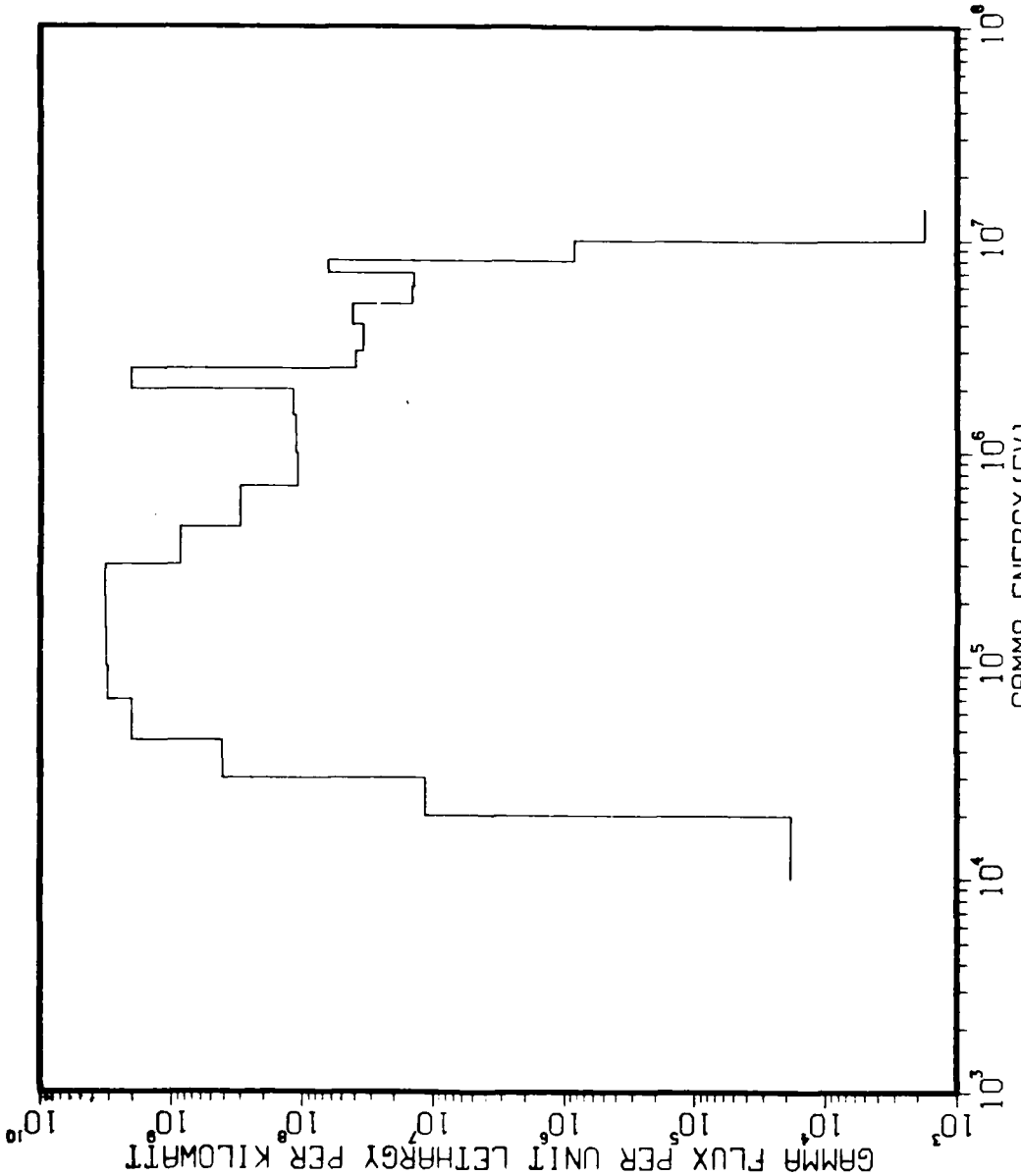

Figure II.3.46. Back Gamma Flux vs Energy at Center of Pneumatic Tubes.

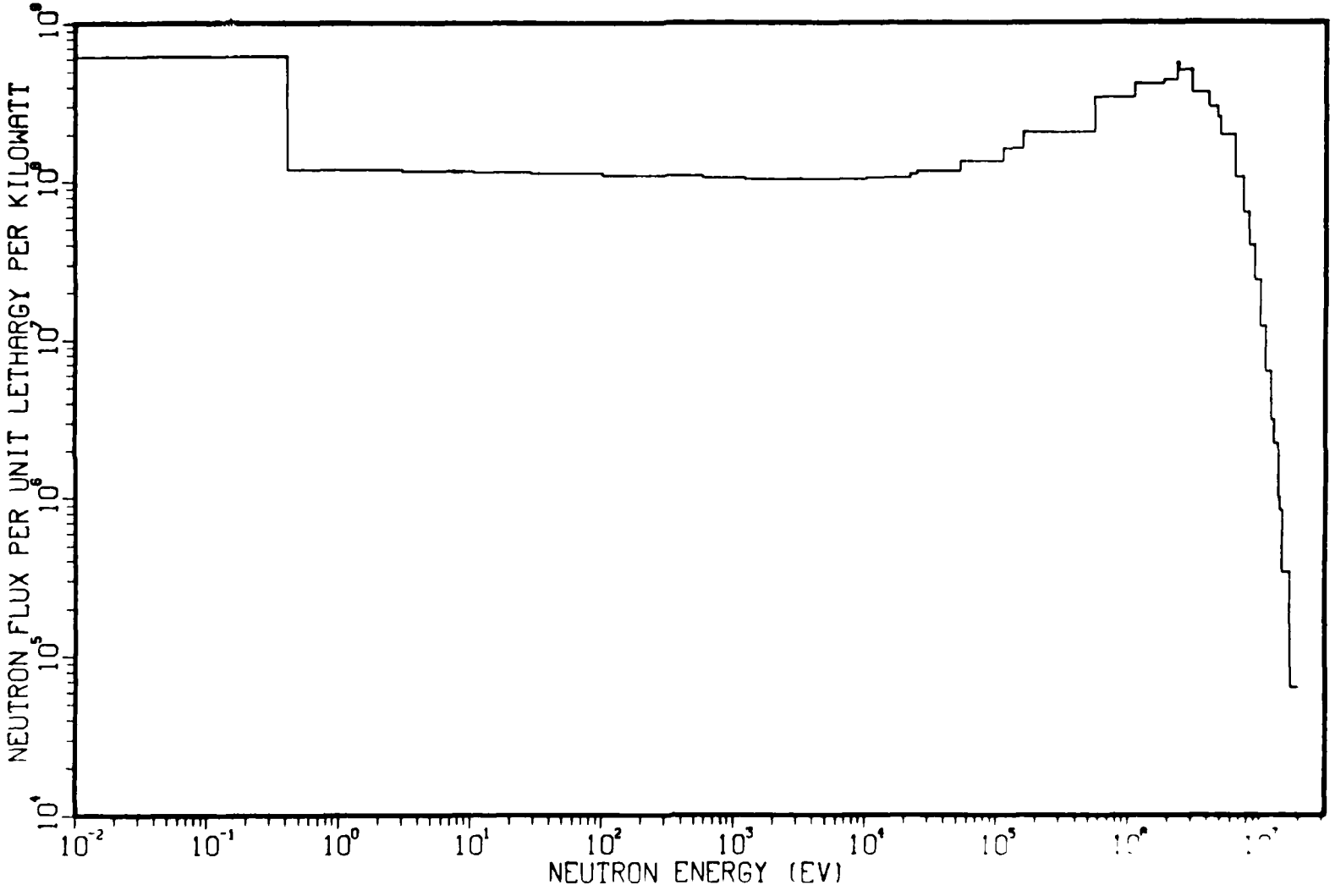

Figure II.3.47. Total (Front+Back, 1-D) Neutron Flux vs Energy at Center of Pneumatic Tubes

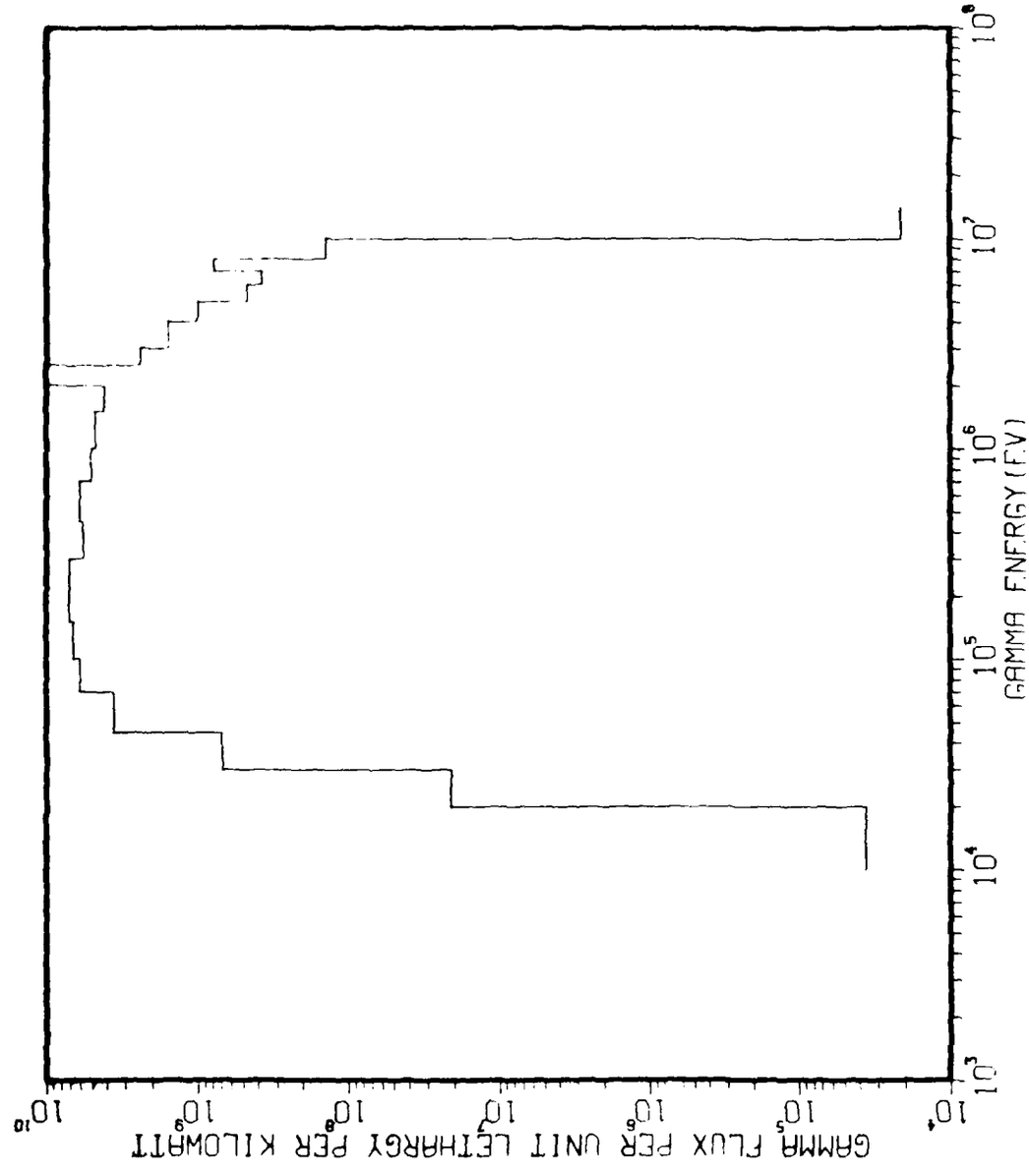

Figure II.3.48. Total (Front+Back) Gamma Flux vs Energy at Center of Pneumatic Tubes.

Table II.3.25. Neutron Flux Per Unit Lethargy Per Kilowatt.

		PNEUMATIC TUBES NEAR ER2		
GROUP	ENERGY (EV)	FRONT	BACK	TOTAL
1	1.960E+07	6.26E+04	7.35E+02	6.34E+04
2	1.690E+07	3.35E+05	3.95E+03	3.38E+05
3	1.490E+07	8.25E+05	1.05E+04	8.36E+05
4	1.420E+07	9.91E+05	1.17E+04	1.00E+06
5	1.380E+07	2.17E+06	2.52E+04	2.20E+06
6	1.280E+07	3.03E+06	4.24E+04	3.07E+06
7	1.220E+07	6.18E+06	8.75E+04	6.27E+06
8	1.110E+07	1.19E+07	1.83E+05	1.21E+07
9	1.000E+07	2.32E+07	4.65E+05	2.37E+07
10	9.050E+06	3.83E+07	9.37E+05	3.92E+07
11	8.190E+06	6.15E+07	1.61E+06	6.31E+07
12	7.410E+06	1.02E+08	3.39E+06	1.06E+08
13	6.380E+06	1.88E+08	8.71E+06	1.96E+08
14	4.970E+06	2.40E+08	1.34E+07	2.54E+08
15	4.720E+06	2.80E+08	1.52E+07	2.95E+08
16	4.070E+06	3.36E+08	2.65E+07	3.62E+08
17	3.010E+06	4.52E+08	4.52E+07	4.97E+08
18	2.390E+06	5.13E+08	3.83E+07	5.52E+08
19	2.310E+06	4.00E+08	3.15E+07	4.32E+08
20	1.830E+06	3.61E+08	4.99E+07	4.11E+08
21	1.110E+06	2.74E+08	6.32E+07	3.37E+08
22	5.500E+05	1.53E+08	5.01E+07	2.03E+08
23	1.580E+05	1.15E+08	4.58E+07	1.61E+08
24	1.110E+05	9.36E+07	4.02E+07	1.34E+08
25	5.250E+04	7.75E+07	3.77E+07	1.15E+08
26	2.480E+04	7.45E+07	3.59E+07	1.10E+08
27	2.190E+04	7.01E+07	3.52E+07	1.05E+08
28	1.030E+04	6.73E+07	3.60E+07	1.03E+08
29	3.350E+03	6.67E+07	3.70E+07	1.04E+08
30	1.230E+03	6.76E+07	3.84E+07	1.06E+08
31	5.830E+02	6.88E+07	4.00E+07	1.09E+08
32	1.010E+02	7.06E+07	4.18E+07	1.12E+08
33	2.900E+01	7.19E+07	4.31E+07	1.15E+08
34	1.070E+01	7.27E+07	4.41E+07	1.17E+08
35	3.060E+00	7.39E+07	4.53E+07	1.19E+08
36	1.130E+00	7.38E+07	4.58E+07	1.20E+08
37	4.140E-01	3.17E+08	3.00E+08	6.17E+08

Table II.3.26. Gamma Flux Per Unit Lethargy Per Kilowatt.

PNEUMATIC TUBES NEAR ER2

GROUP	ENERGY (EV)	FRONT	BACK	TOTAL
1	1.400E+07	1.94E+04	1.78E+03	2.12E+04
2	1.000E+07	1.41E+08	8.34E+05	1.42E+08
3	8.000E+06	7.16E+08	6.29E+07	7.79E+08
4	7.000E+06	3.65E+08	1.42E+07	3.79E+08
5	6.000E+06	4.55E+08	1.46E+07	4.69E+08
6	5.000E+06	9.56E+08	4.17E+07	9.98E+08
7	4.000E+06	1.52E+09	3.42E+07	1.55E+09
8	3.000E+06	2.38E+09	3.91E+07	2.42E+09
9	2.500E+06	7.77E+09	2.03E+09	9.80E+09
10	2.000E+06	4.01E+09	1.18E+08	4.12E+09
11	1.500E+06	4.64E+09	1.12E+08	4.76E+09
12	1.000E+06	4.95E+09	1.10E+08	5.06E+09
13	7.000E+05	5.67E+09	3.01E+08	5.97E+09
14	4.500E+05	4.84E+09	8.56E+08	5.70E+09
15	3.000E+05	3.88E+09	3.18E+09	7.06E+09
16	1.500E+05	3.52E+09	3.14E+09	6.65E+09
17	1.000E+05	2.92E+09	3.08E+09	5.99E+09
18	7.000E+04	1.57E+09	2.01E+09	3.58E+09
19	4.500E+04	2.83E+08	4.04E+08	6.87E+08
20	3.000E+04	9.69E+06	1.15E+07	2.12E+07
21	2.000E+04	1.73E+04	1.87E+04	3.60E+04

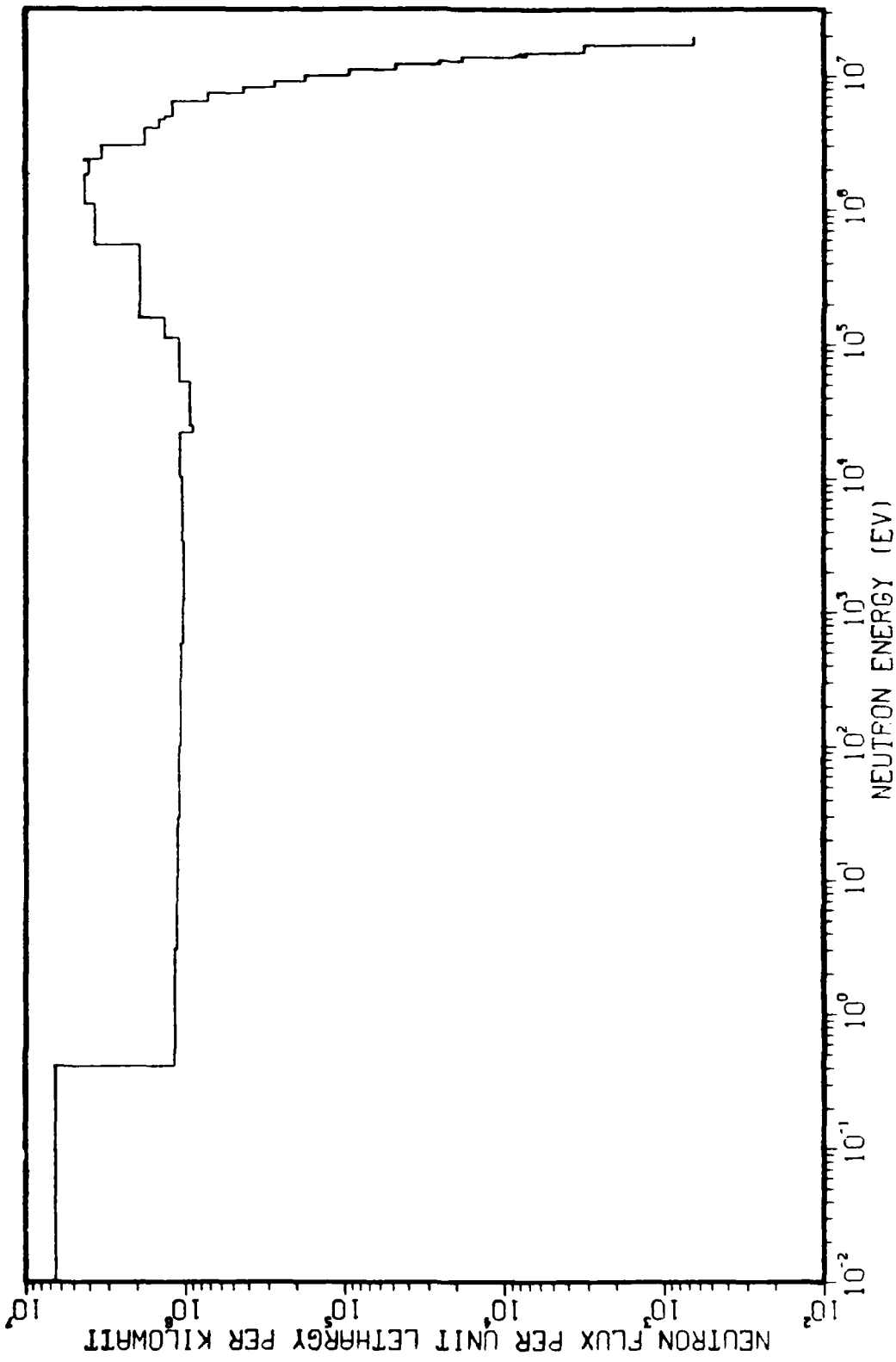

Figure II.3.49. Front (1-D) Neutron Flux vs Energy ER1 With 6" PB and Phantom.

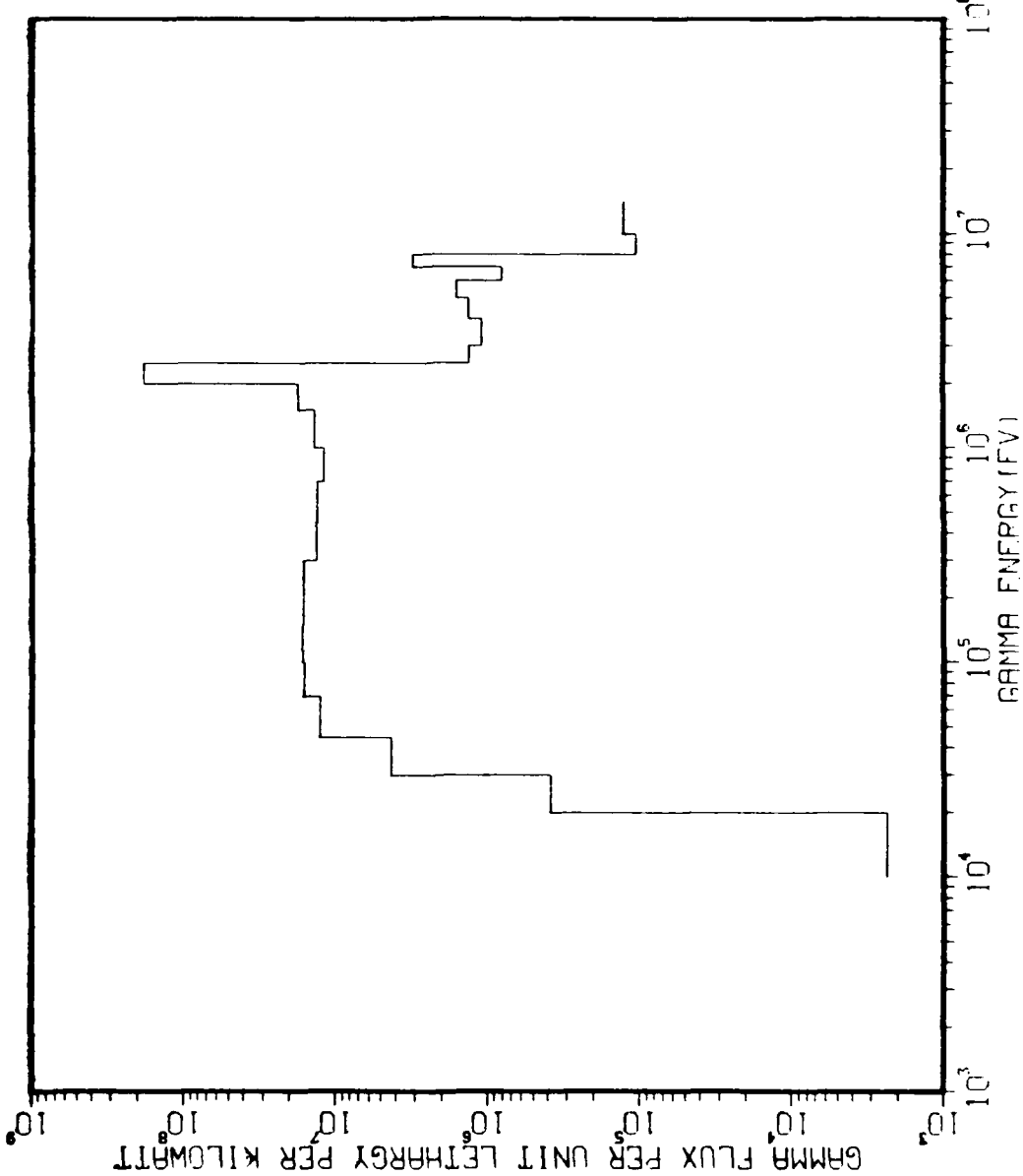

Figure II.3.50. Front Gamma Flux vs Energy ERI With 6" PB and Phantom.

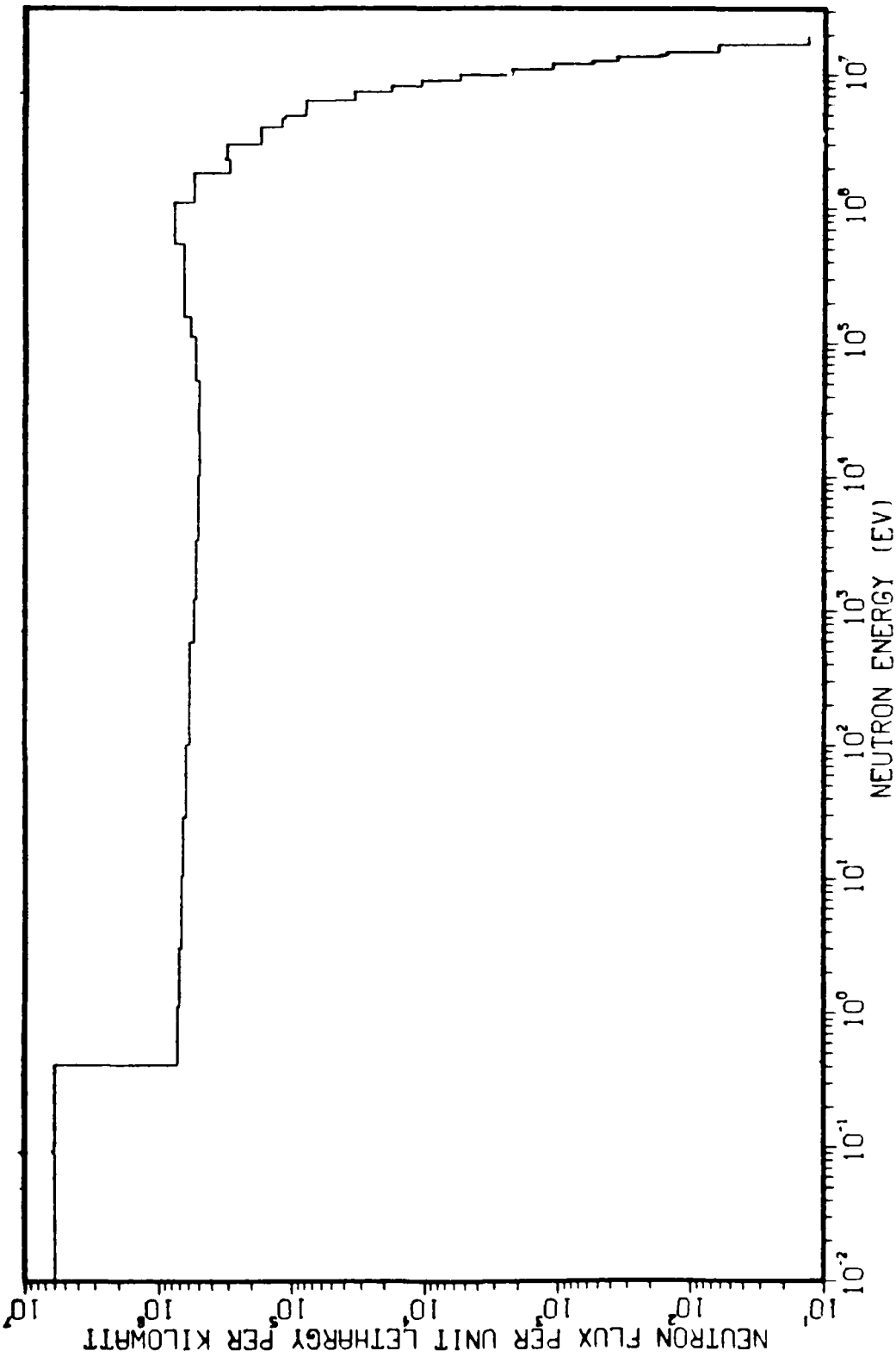

Figure II.3.51. Back (1-D) Neutron Flux vs Energy ER1 With 6" PB and Phantom.

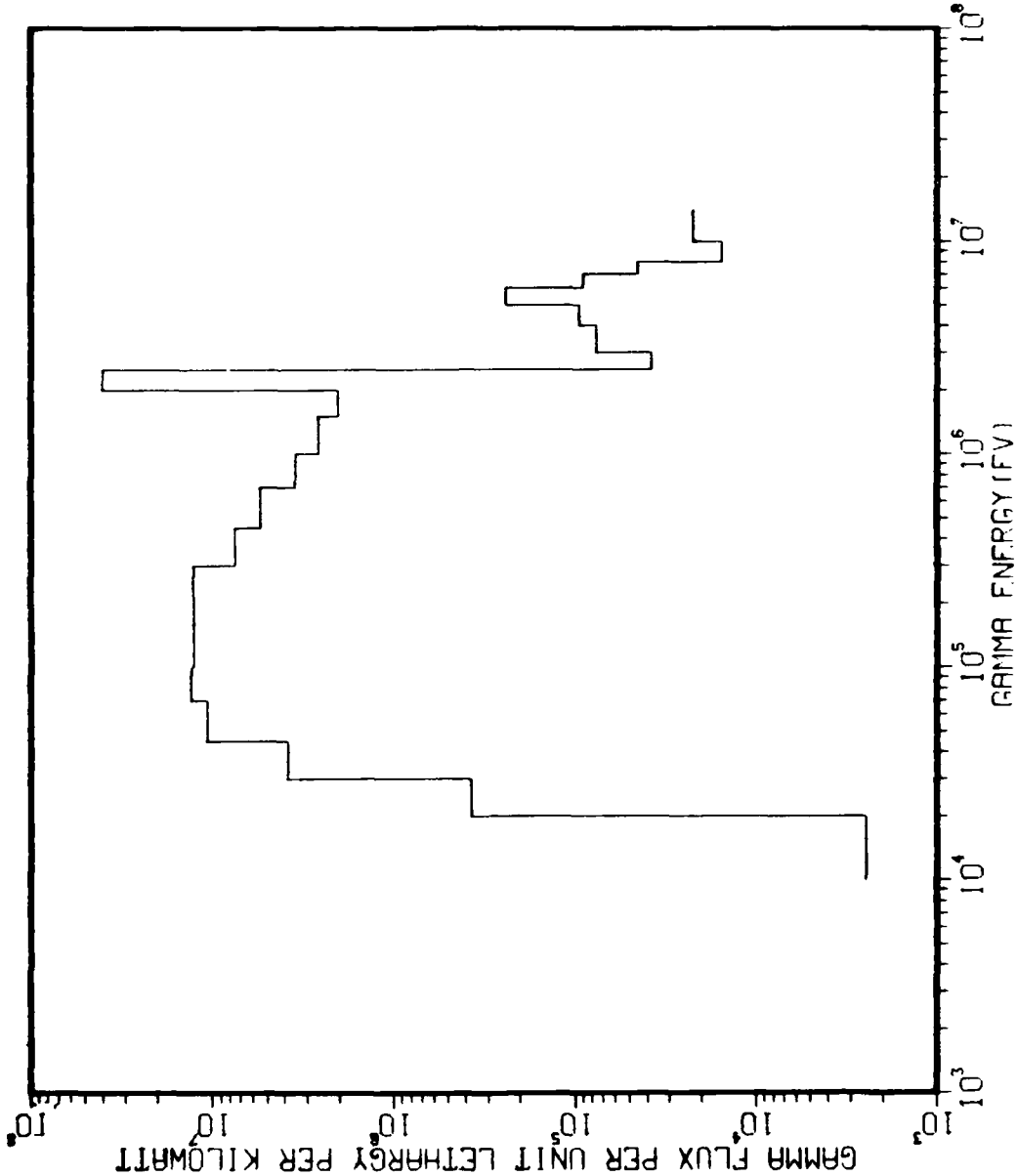

Figure II.3.52. Back Gamma Flux vs Energy ER1 With 6" PB and Phantom.

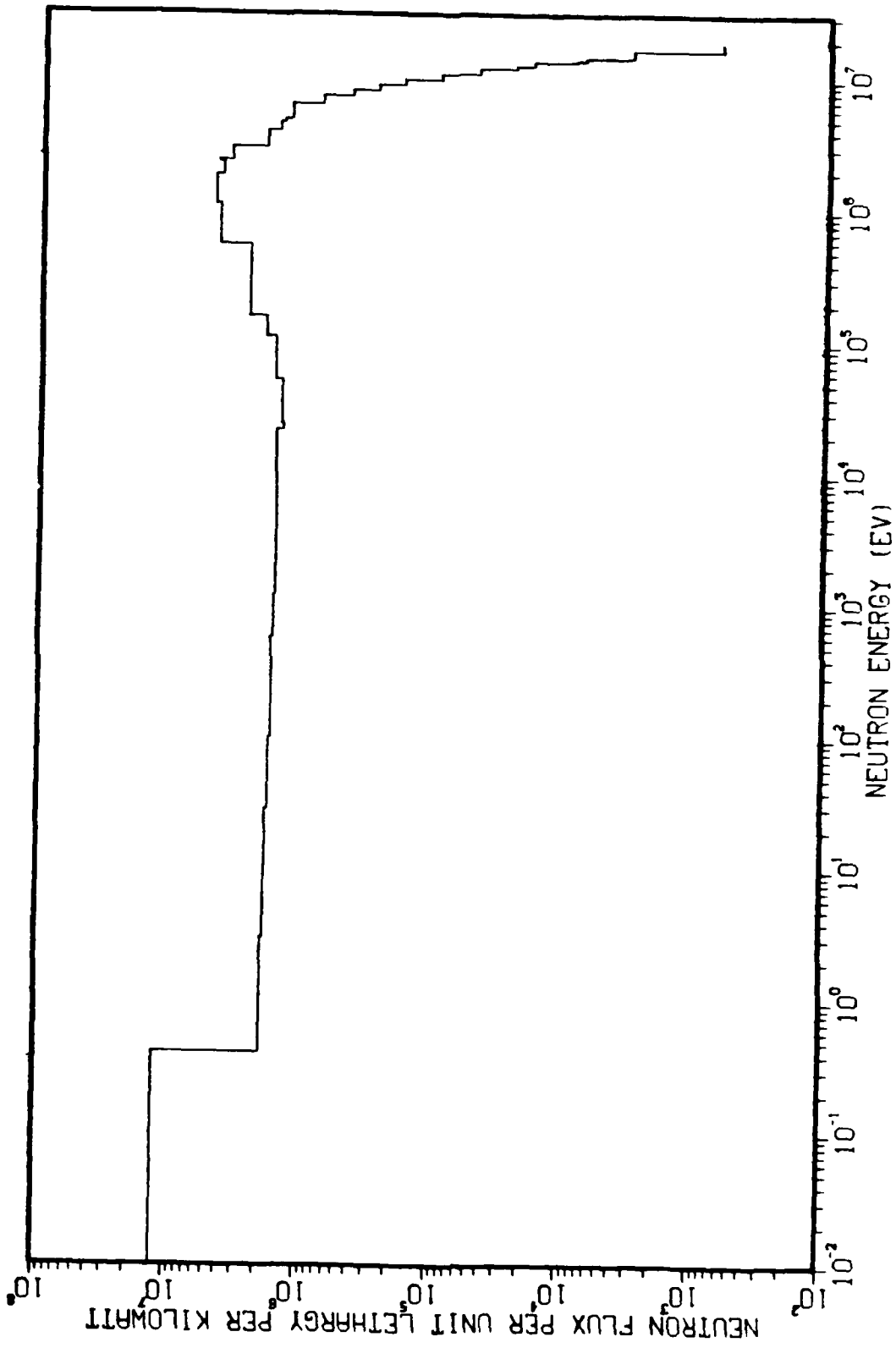

Figure II.3.53. Total (Front+Back, 1-D) Neutron Flux vs Energy ER1 With 6" PB and Phantom.

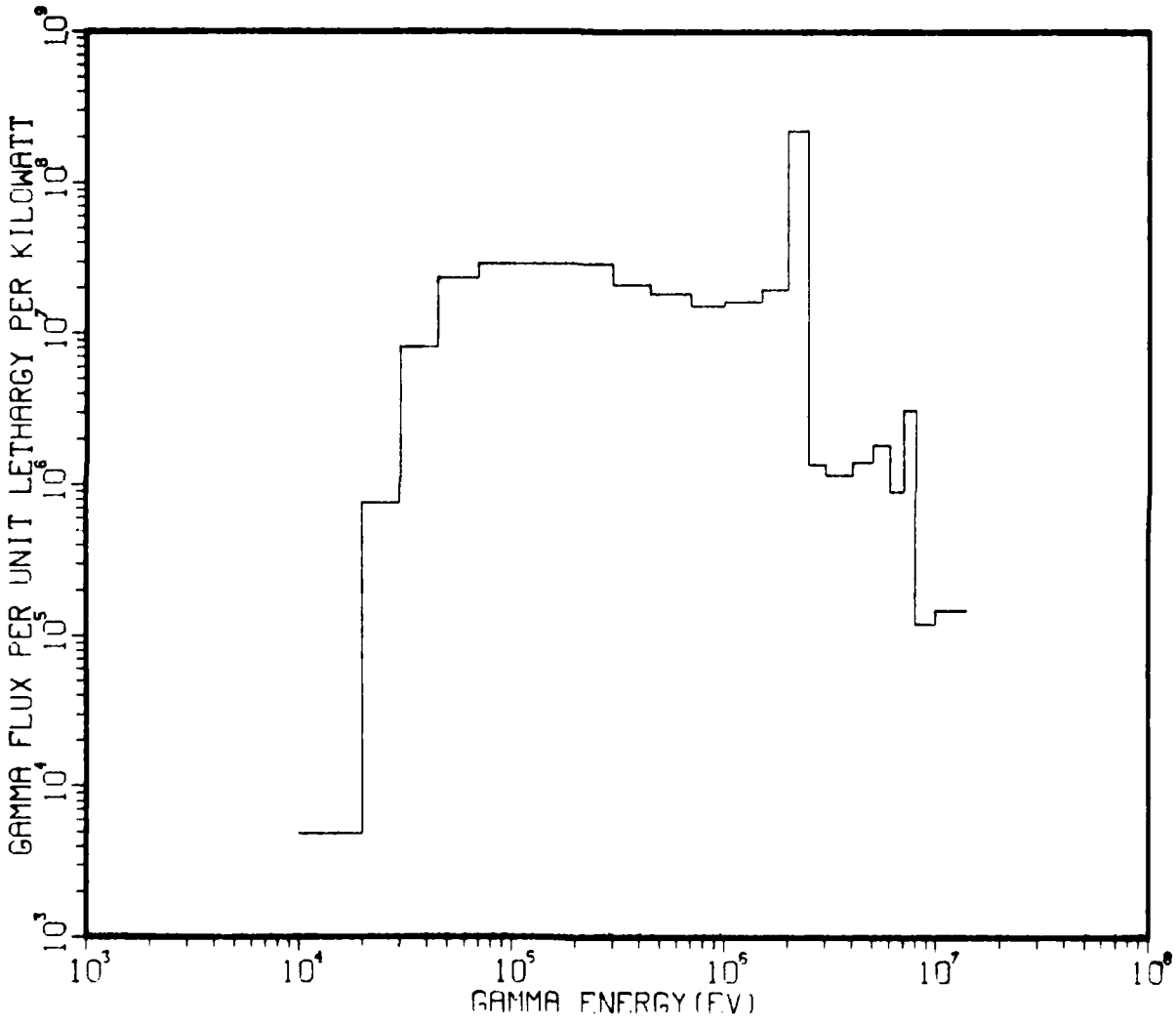

Figure II.3.54. Total (Front+Back) Gamma Flux vs Energy ER1 With 6" in PB and Phantom.

Table II.3.27. Neutron Flux Per Unit LEthargy Per Kilowatt.

ER1 With 6" Pb and Phantom

GROUP	ENERGY (EV)	FRONT	BACK	TOTAL
1	1.96ØE+Ø7	6.55E+Ø2	1.35E+Ø1	6.68E+Ø2
2	1.69ØE+Ø7	3.2ØE+Ø3	6.27E+Ø1	3.26E+Ø3
3	1.49ØE+Ø7	7.37E+Ø3	1.63E+Ø2	7.53E+Ø3
4	1.42ØE+Ø7	8.51E+Ø3	1.7ØE+Ø2	8.68E+Ø3
5	1.38ØE+Ø7	1.85E+Ø4	3.59E+Ø2	1.88E+Ø4
6	1.28ØE+Ø7	2.54E+Ø4	5.49E+Ø2	2.6ØE+Ø4
7	1.22ØE+Ø7	4.81E+Ø4	1.1ØE+Ø3	4.92E+Ø4
8	1.11ØE+Ø7	9.38E+Ø4	2.24E+Ø3	9.6ØE+Ø4
9	1.ØØØE+Ø7	1.77E+Ø5	6.52E+Ø3	1.82E+Ø5
1Ø	9.Ø5ØE+Ø6	2.77E+Ø5	1.ØØE+Ø4	2.87E+Ø5
11	8.19ØE+Ø6	4.32E+Ø5	1.ØØE+Ø4	4.5ØE+Ø5
12	7.41ØE+Ø6	7.22E+Ø5	3.41E+Ø4	7.56E+Ø5
13	6.38ØE+Ø6	1.2ØE+Ø6	7.96E+Ø4	1.28E+Ø6
14	4.97ØE+Ø6	1.36E+Ø6	1.14E+Ø5	1.47E+Ø6
15	4.72ØE+Ø6	1.46E+Ø6	1.19E+Ø5	1.58E+Ø6
16	4.Ø7ØE+Ø6	1.8ØE+Ø6	1.73E+Ø5	1.98E+Ø6
17	3.Ø1ØE+Ø6	3.33E+Ø6	3.12E+Ø5	3.64E+Ø6
18	2.39ØE+Ø6	4.33E+Ø6	3.2ØE+Ø5	4.65E+Ø6
19	2.31ØE+Ø6	4.Ø1E+Ø6	2.96E+Ø5	4.31E+Ø6
2Ø	1.83ØE+Ø6	4.3ØE+Ø6	5.52E+Ø5	4.85E+Ø6
21	1.11ØE+Ø6	3.69E+Ø6	7.71E+Ø5	4.46E+Ø6
22	5.5ØØE+Ø5	1.93E+Ø6	6.54E+Ø5	2.58E+Ø6
23	1.58ØE+Ø5	1.35E+Ø6	5.8ØE+Ø5	1.94E+Ø6
24	1.11ØE+Ø5	1.1ØE+Ø6	5.36E+Ø5	1.64E+Ø6
25	5.25ØE+Ø4	9.43E+Ø5	5.Ø7E+Ø5	1.45E+Ø6
26	2.48ØE+Ø4	9.Ø1E+Ø5	5.Ø5E+Ø5	1.41E+Ø6
27	2.19ØE+Ø4	1.Ø9E+Ø6	4.99E+Ø5	1.58E+Ø6
28	1.Ø3ØE+Ø4	1.Ø5E+Ø6	5.14E+Ø5	1.56E+Ø6
29	3.35ØE+Ø3	1.Ø3E+Ø6	5.33E+Ø5	1.57E+Ø6
3Ø	1.23ØE+Ø3	1.Ø5E+Ø6	5.54E+Ø5	1.6ØE+Ø6
31	5.83ØE+Ø2	1.Ø7E+Ø6	5.94E+Ø5	1.66E-Ø
32	1.Ø1ØE+Ø2	1.1ØE+Ø6	6.33E+Ø5	1.74E+Ø6
33	2.9ØØE+Ø1	1.12E+Ø6	6.61E+Ø5	1.78E+Ø6
34	1.Ø7ØE+Ø1	1.14E+Ø6	6.84E+Ø5	1.82E+Ø6
35	3.Ø6ØE+ØØ	1.16E+Ø6	7.1ØE+Ø5	1.87E+Ø5
36	1.13ØE+ØØ	1.17E+Ø6	7.24E+Ø5	1.9ØE+Ø6
37	4.14ØE-Ø1	6.6ØE+Ø6	6.Ø1E+Ø6	1.25E+Ø7

Table II.3.28. Gamma Flux Per Unit Lethargy Per Kilowatt.

ER1 With 6" Pb and Phantom

GROUP	ENERGY (EV)	FRONT	BACK	TOTAL
1	1.400E+07	1.26E+05	2.21E+04	1.48E+05
2	1.000E+07	1.05E+05	1.55E+04	1.20E+05
3	8.000E+06	3.06E+06	4.52E+04	3.11E+06
4	7.000E+06	8.13E+05	9.01E+04	9.04E+05
5	6.000E+06	1.60E+06	2.39E+05	1.83E+06
6	5.000E+06	1.32E+06	9.47E+04	1.41E+06
7	4.000E+06	1.08E+06	7.64E+04	1.16E+06
8	3.000E+06	1.31E+06	3.78E+04	1.35E+06
9	2.500E+06	1.82E+08	4.02E+07	2.22E+08
10	2.000E+06	1.76E+07	2.03E+06	1.96E+07
11	1.500E+06	1.36E+07	2.60E+06	1.62E+07
12	1.000E+06	1.18E+07	3.52E+06	1.53E+07
13	7.000E+05	1.30E+07	5.49E+06	1.85E+07
14	4.500E+05	1.34E+07	7.56E+06	2.10E+07
15	3.000E+05	1.62E+07	1.27E+07	2.89E+07
16	1.500E+05	1.64E+07	1.27E+07	2.91E+07
17	1.000E+05	1.60E+07	1.31E+07	2.91E+07
18	7.000E+04	1.25E+07	1.07E+07	2.32E+07
19	4.500E+04	4.30E+06	3.85E+06	8.16E+06
20	3.000E+04	3.86E+05	3.71E+05	7.57E+05
21	2.000E+04	2.36E+03	2.48E+03	4.83E+03

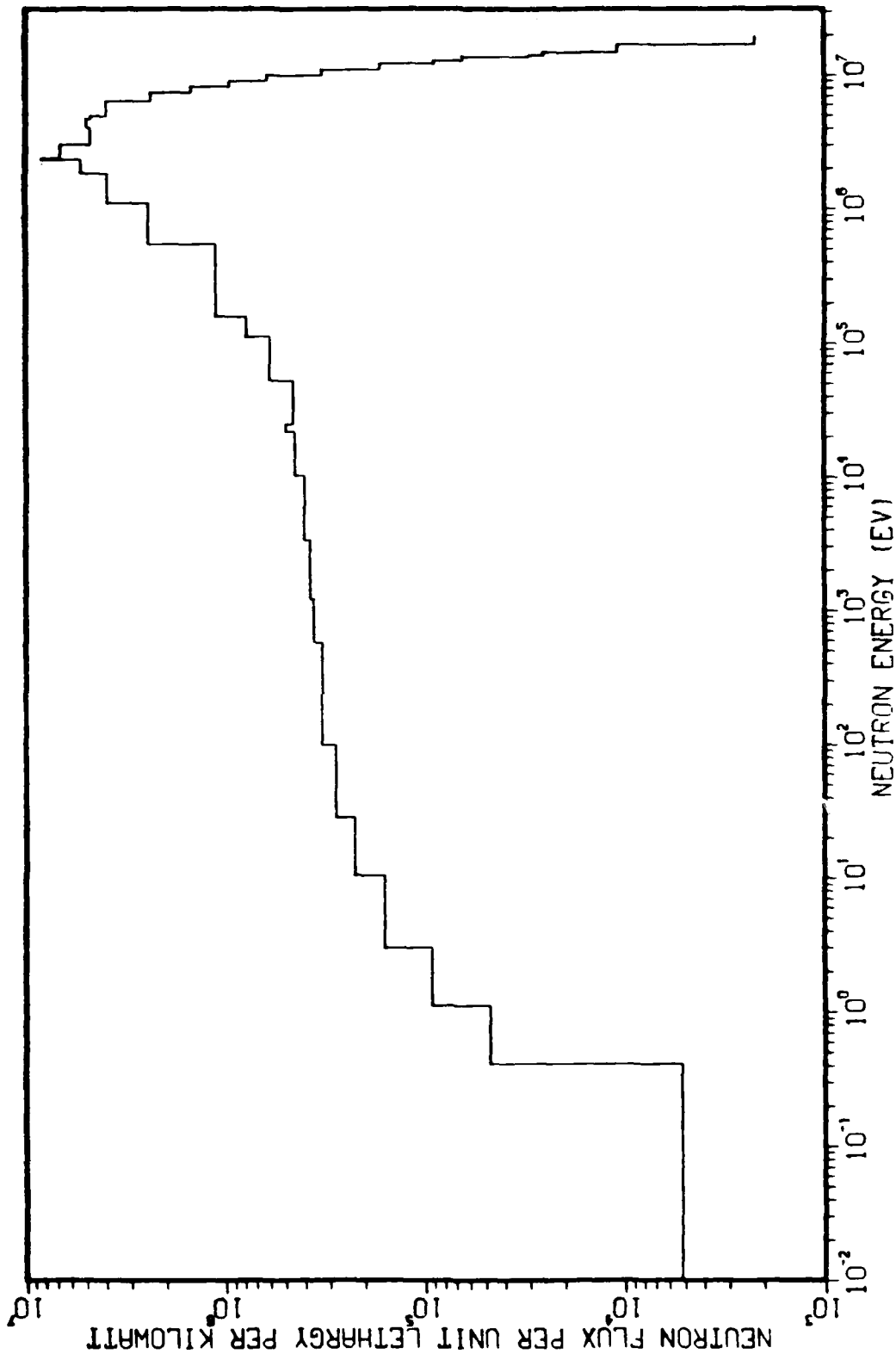

Figure II.3.55. Front (1-D) Neutron Flux vs Energy ER1 With 5" Water.

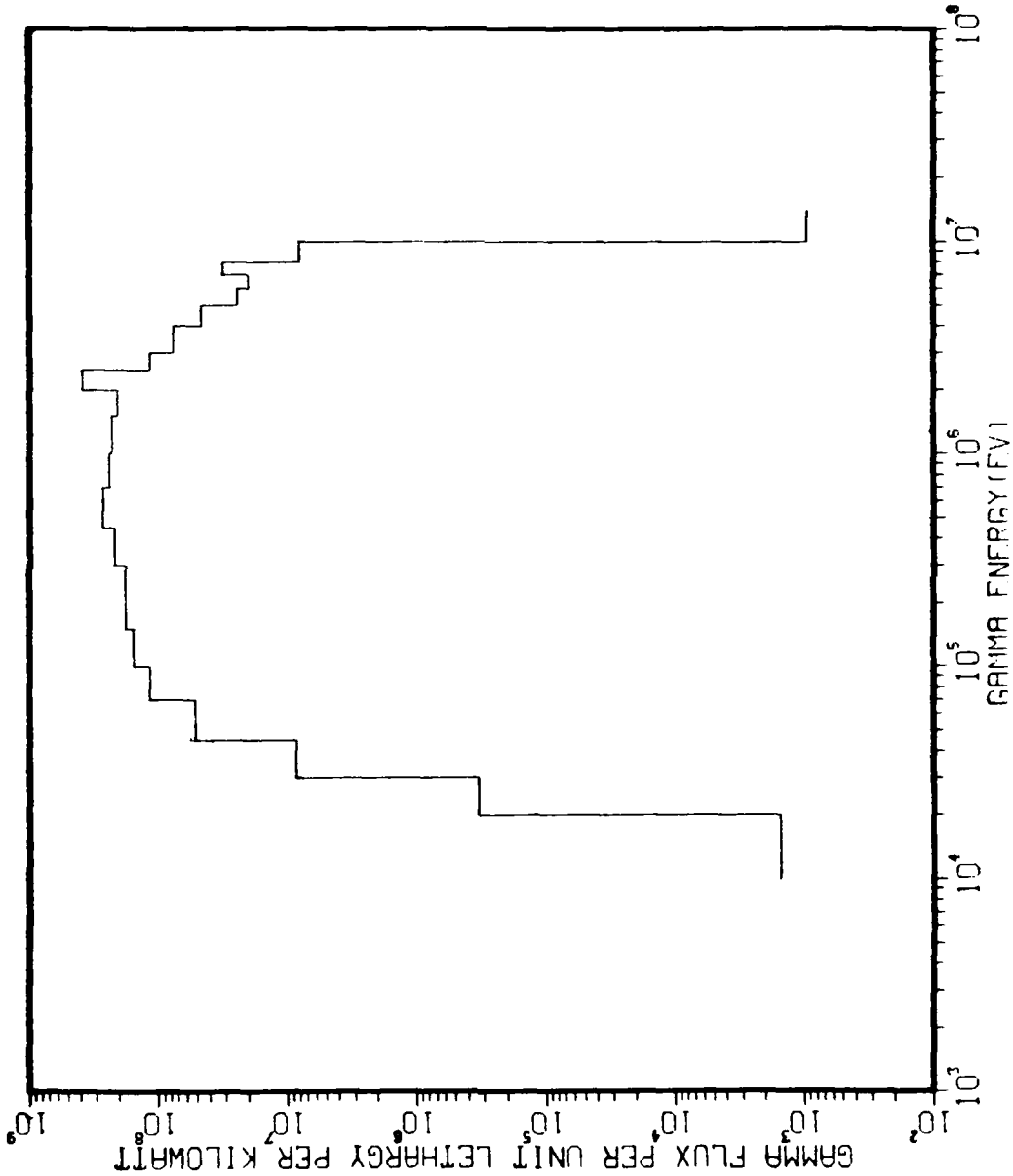

Figure II.3.56. Front Gamma Flux vs Energy ER1 With 5" Water.

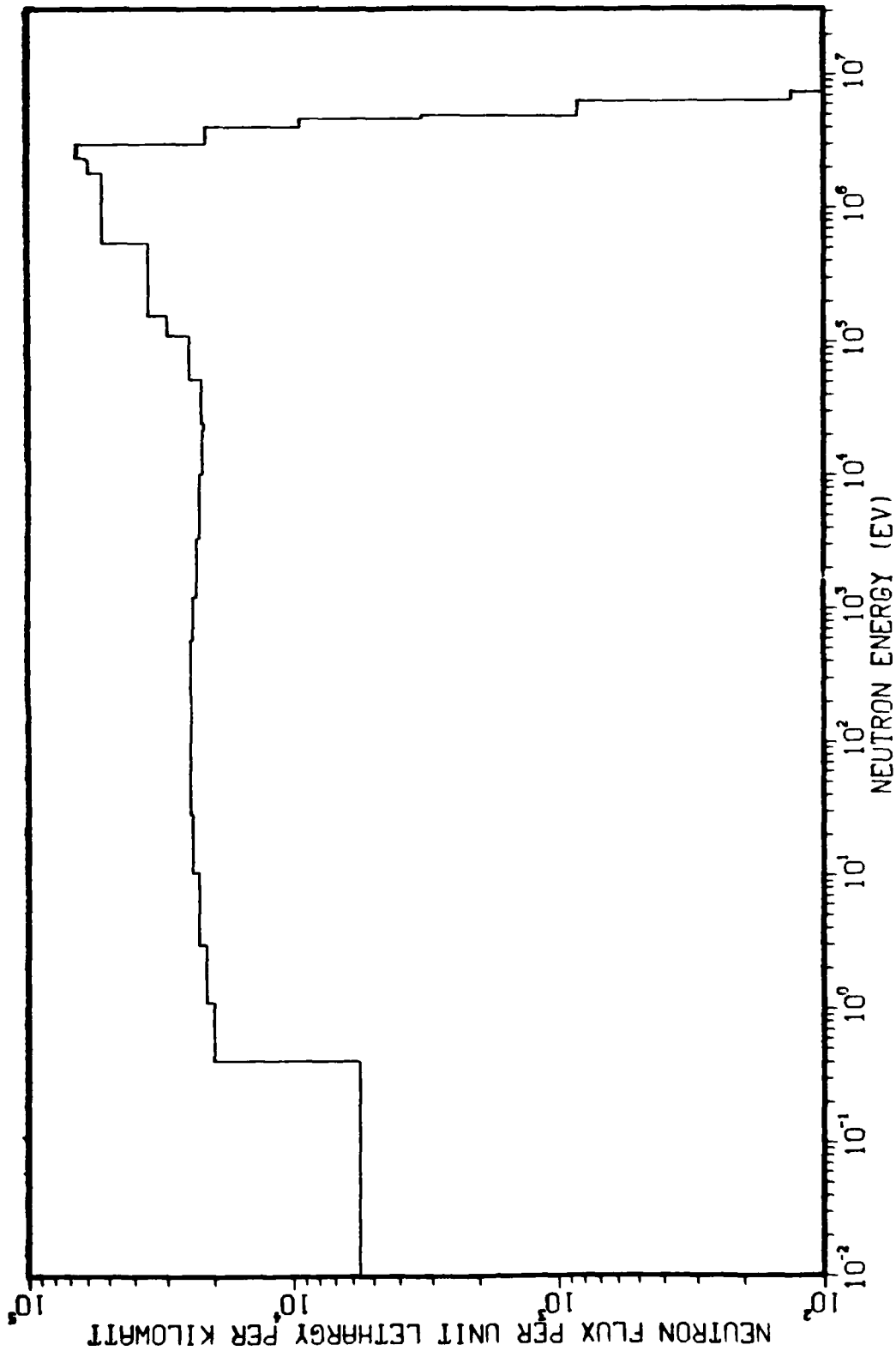

Figure II.3.57. Back (1-D) Neutron Flux vs Energy ER1 With 5" Water.

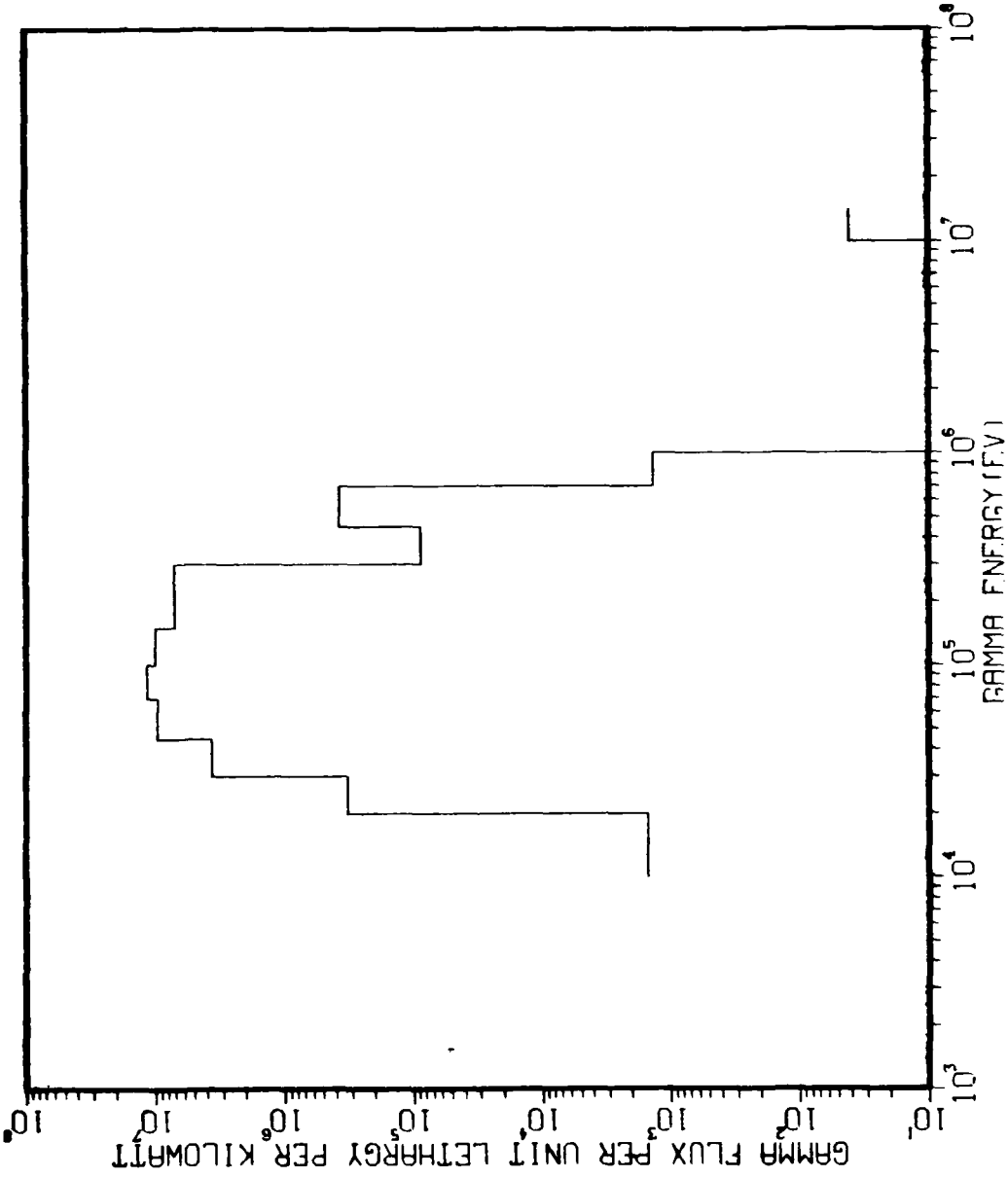

Figure II.3.58. Back Gamma Flux vs Energy ER1 With 5" Water.

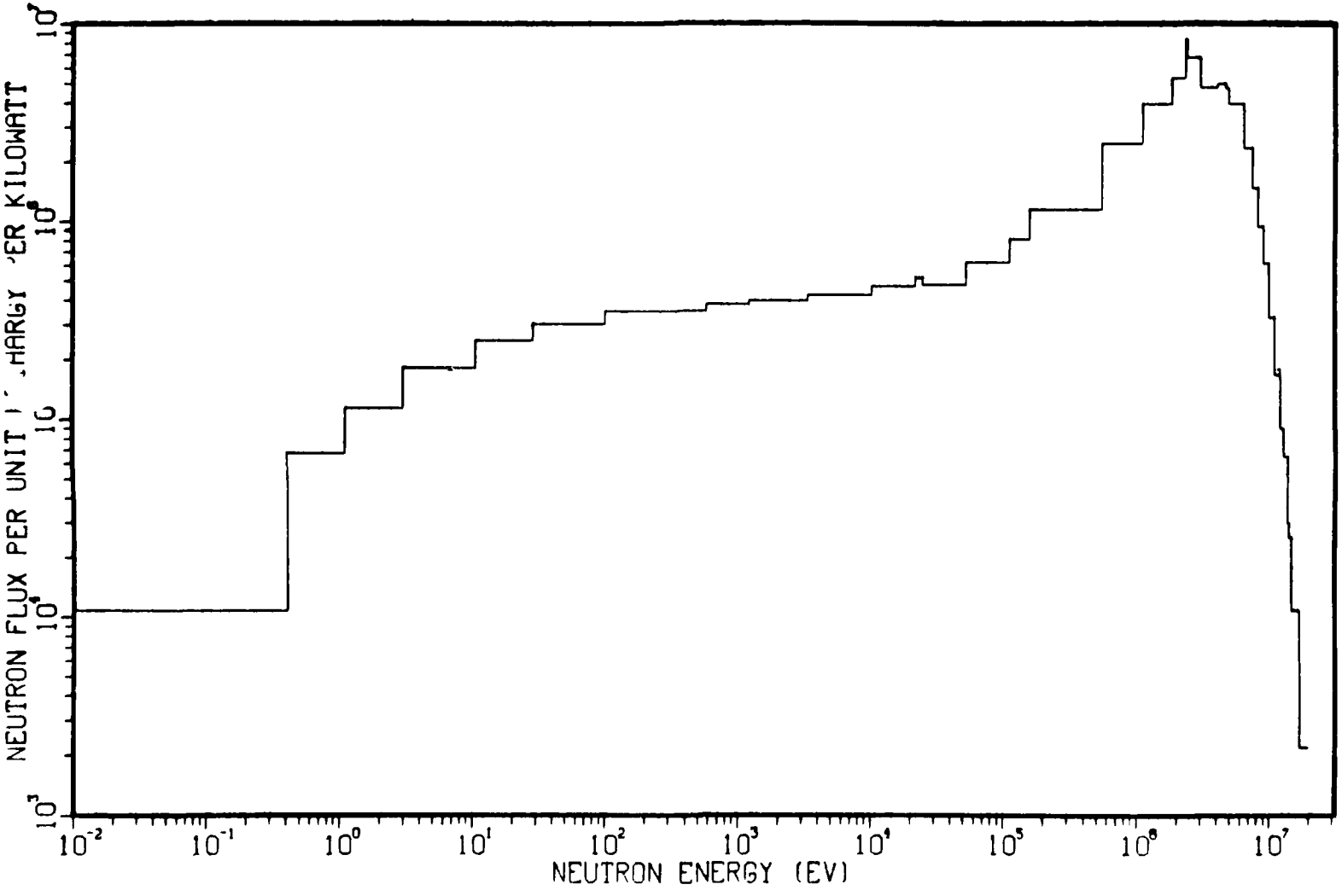

Figure II.3.59. Total (Front+Back, 1-D) Neutron Flux vs Energy ER1 With 5" Water.

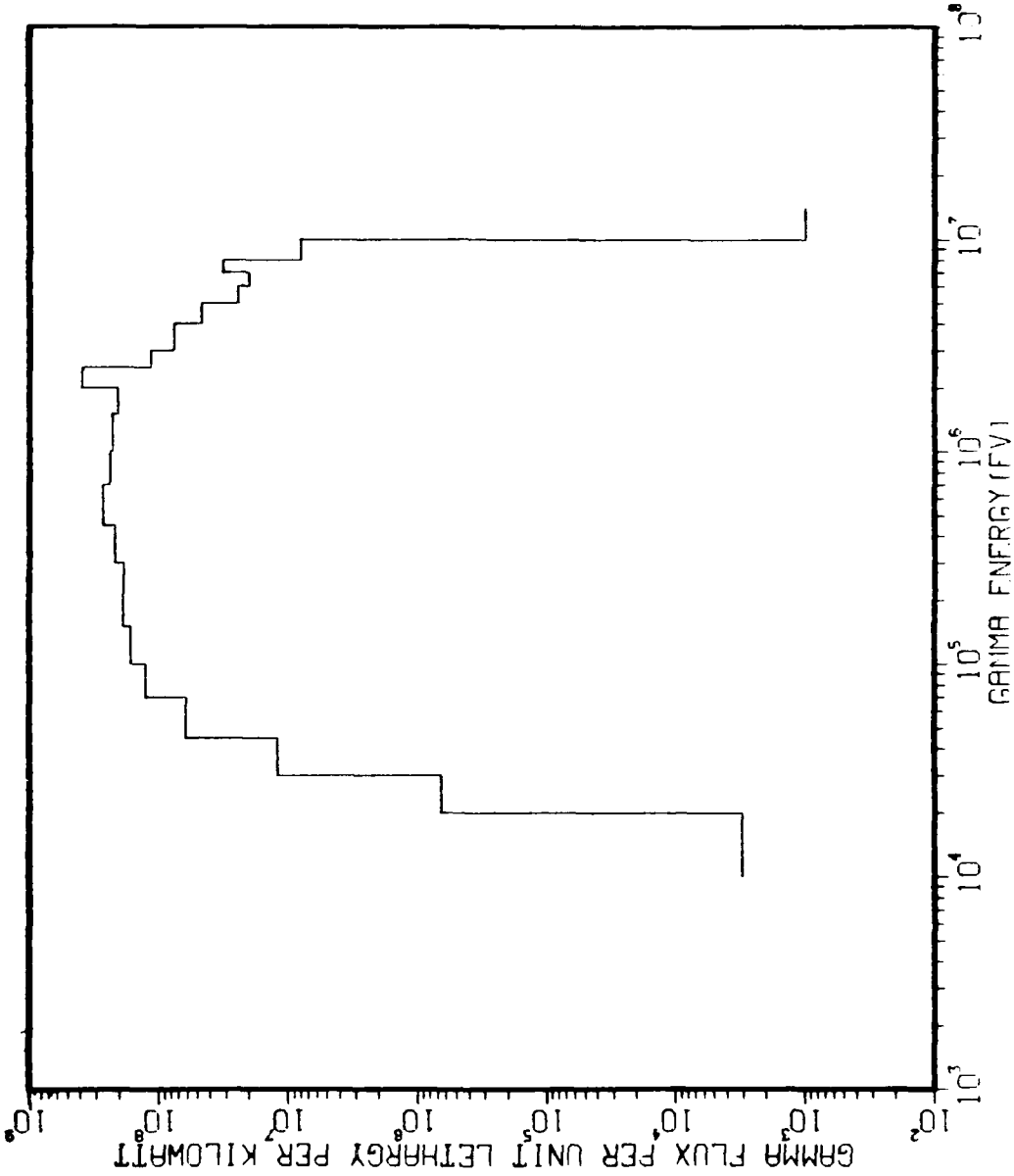

Figure II.3.60. Total (Front+Back) Gamma Flux vs Energy ERI With 5" Water.

Table II.3.29. Neutron Flux Per Unit Lethargy Per Kilowatt.

Free Field in ER1 With Core Moved Bach 5 Inches

GROUP	ENERGY (EV)	FRONT	BACK	TOTAL
1	1.96ØE+Ø7	2.22E+Ø3	Ø.ØØE+ØØ	2.22E+Ø3
2	1.69ØE+Ø7	1.Ø9E+Ø4	Ø.ØØE+ØØ	1.Ø9E+Ø4
3	1.49ØE+Ø7	2.55E+Ø4	Ø.ØØE+ØØ	2.55E+Ø4
4	1.42ØE+Ø7	2.99E+Ø4	Ø.ØØE+ØØ	2.99E+Ø4
5	1.38ØE+Ø7	6.47E+Ø4	Ø.ØØE+ØØ	6.47E+Ø4
6	1.28ØE+Ø7	9.Ø7E+Ø4	Ø.ØØE+ØØ	9.Ø7E+Ø4
7	1.22ØE+Ø7	1.68E+Ø5	Ø.ØØE+ØØ	1.68E+Ø5
8	1.11ØE+Ø7	3.3ØE+Ø5	Ø.ØØE+ØØ	3.3ØE+Ø5
9	1.ØØØE+Ø7	6.23E+Ø5	Ø.ØØE+ØØ	6.23E+Ø5
1Ø	9.Ø5ØE+Ø6	9.5ØE+Ø5	Ø.ØØE+ØØ	9.5ØE+Ø5
11	8.19ØE+Ø6	1.48E+Ø6	Ø.ØØE+ØØ	1.48E+Ø6
12	7.41ØE+Ø6	2.37E+Ø6	1.32E+Ø2	2.37E+Ø6
13	6.38ØE+Ø6	3.96E+Ø6	8.47E+Ø2	3.97E+Ø6
14	4.97ØE+Ø6	4.73E+Ø6	3.26E+Ø3	4.74E+Ø6
15	4.72ØE+Ø6	4.97E+Ø6	9.42E+Ø3	4.98E+Ø6
16	4.Ø7ØE+Ø6	4.76E+Ø6	2.14E+Ø4	4.78E+Ø6
17	3.Ø1ØE+Ø6	6.72E+Ø6	6.5ØE+Ø4	6.78E+Ø6
18	2.39ØE+Ø6	8.28E+Ø6	6.Ø3E+Ø4	8.34E+Ø6
19	2.31ØE+Ø6	5.29E+Ø6	5.89E+Ø4	5.35E+Ø6
2Ø	1.83ØE+Ø6	3.89E+Ø6	5.26E+Ø4	3.94E+Ø6
21	1.11ØE+Ø6	2.44E+Ø6	5.24E+Ø4	2.49E+Ø6
22	5.5ØØE+Ø5	1.13E+Ø6	3.51E+Ø4	1.16E+Ø6
23	1.58ØE+Ø5	7.9ØE+Ø5	2.98E+Ø4	8.2ØE+Ø5
24	1.11ØE+Ø5	6.Ø2E+Ø5	2.46E+Ø4	6.27E+Ø5
25	5.25ØE+Ø4	4.59E+Ø5	2.23E+Ø4	4.81E+Ø5
26	2.48ØE+Ø4	4.98E+Ø5	2.18E+Ø4	5.2ØE+Ø5
27	2.19ØE+Ø4	4.5ØE+Ø5	2.21E+Ø4	4.72E+Ø5
28	1.Ø3ØE+Ø4	4.Ø4E+Ø5	2.26E+Ø4	4.27E+Ø5
29	3.35ØE+Ø3	3.78E+Ø5	2.32E+Ø4	4.Ø2E+Ø5
3Ø	1.23ØE+Ø3	3.62E+Ø5	2.39E+Ø4	3.86E+Ø5
31	5.83ØE+Ø2	3.29E+Ø5	2.44E+Ø4	3.53E+Ø5
32	1.Ø1ØE+Ø2	2.8ØE+Ø5	2.46E+Ø4	3.Ø6E+Ø5
33	2.98ØE+Ø1	2.28E+Ø5	2.41E+Ø4	2.52E+Ø5
34	1.Ø7ØE+Ø1	1.61E+Ø5	2.28E+Ø4	1.84E+Ø5
35	3.Ø6ØE+ØØ	9.33E+Ø4	2.14E+Ø4	1.15E+Ø5
36	1.13ØE+ØØ	4.77E+Ø4	2.ØØE+Ø4	6.77E+Ø4
37	4.14ØE-Ø1	6.22E+Ø3	6.63E+Ø3	1.Ø9E+Ø4

Table II.3.30. Gamma Flux Per Unit Lethargy Per Kilowatt.

Free Field in ER1 With Core Moved Back 5 Inches

GROUP	ENERGY (EV)	FRONT	BACK	TOTAL
1	1.400E+07	9.57E+02	4.08E+01	9.98E+02
2	1.000E+07	8.08E+06	0.00E+00	8.08E+06
3	8.000E+06	3.17E+07	0.00E+00	3.17E+07
4	7.000E+06	2.00E+07	0.00E+00	2.00E+07
5	6.000E+06	2.44E+07	0.00E+00	2.44E+07
6	5.000E+06	4.69E+07	0.00E+00	4.69E+07
7	4.000E+06	7.63E+07	0.00E+00	7.63E+07
8	3.000E+06	1.17E+08	0.00E+00	1.17E+08
9	2.500E+06	3.91E+08	0.00E+00	3.91E+08
10	2.000E+06	2.06E+08	0.00E+00	2.06E+08
11	1.500E+06	2.30E+08	0.00E+00	2.30E+08
12	1.000E+06	2.39E+08	1.38E+03	2.39E+08
13	7.000E+05	2.68E+08	3.79E+05	2.68E+08
14	4.500E+05	2.18E+08	8.78E+04	2.18E+08
15	3.000E+05	1.79E+08	7.16E+06	1.86E+08
16	1.500E+05	1.54E+08	9.99E+06	1.64E+08
17	1.000E+05	1.16E+08	1.16E+07	1.27E+08
18	7.000E+04	5.22E+07	9.58E+06	6.18E+07
19	4.500E+04	8.49E+06	3.78E+06	1.22E+07
20	3.000E+04	3.34E+05	3.24E+05	6.59E+05
21	2.000E+04	1.54E+03	1.54E+03	3.07E+03

Table II.3.31. Front Response Per Kilowatt for ANIAN (1-D) Results.

RESPONSE	CASE 1	CASE 2	CASE 3	CASE 4	CASE 5	CASE 6	CASE 7	CASE 8	CASE 9	CASE 10
SULFUR ACTIVATION ACTS/CC-S/ATOM/BN-CM/KW	5.70E+06	1.22E+06	3.03E+05	3.16E+06	5.19E+06	1.66E+05	3.40E+06	7.26E+07	4.60E+05	1.28E+06
SILICON DAMAGE 1 MEV EQUIVALENT N/CM2/S/KW	9.10E+07	5.45E+07	1.03E+08	9.16E+07	8.47E+07	1.73E+06	7.50E+07	1.56E+09	1.85E+07	1.61E+07
NEUTRON DOSE RAD/S/KW	2.91E-01	1.73E-01	3.47E-01	3.93E-01	2.89E-01	5.44E-03	2.39E-01	6.68E+00	9.38E-02	5.08E-02
GAMMA DOSE RAD/S/KW	4.81E-01	1.39E-03	4.77E-04	7.82E-02	4.53E-01	2.08E-01	3.53E-02	7.45E+00	5.16E-02	3.66E-01
NEUTRON DOSE REM/S/KW	2.55E+00	1.62E+00	3.01E+00	2.34E+00	2.32E+00	4.53E-02	2.16E+00	3.90E+01	4.84E-01	4.36E-01
TOTAL DOSE RAD/S/KW	7.72E-01	1.74E-01	3.48E-01	4.71E-01	7.42E-01	2.13E-01	2.74E-01	1.41E+01	1.45E-01	4.17E-01
TOTAL DOSE REM/S/KW	3.03E+00	1.62E+00	3.02E+00	2.42E+00	2.77E+00	2.53E-01	2.20E+00	4.65E+01	4.85E-01	8.02E-01
TOTAL NEUTRON FLUX N/CM2/S/KW	1.11E+08	8.11E+07	2.61E+08	3.67E+08	1.46E+08	1.56E+06	9.79E+07	6.06E+09	1.08E+08	1.64E+07
NEUTRON FLUX >1 MEV N/CM2/S/KW	5.13E+07	2.39E+07	2.14E+07	3.62E+07	4.60E+07	1.02E+06	3.98E+07	6.66E+08	5.86E+06	9.48E+06

Table II.3.32. Back Response Per Kilowatt For ANISN (1-D) Results.

RESPONSE	CASE 1	CASE 2	CASE 3	CASE 4	CASE 5	CASE 6	CASE 7	CASE 8	CASE 9	CASE 10
SULFUR ACTIVATION ACTS/CC-S/ATOM/BN-CM/KW	1.68E+04	3.13E+03	9.63E+04	2.18E+05	2.19E+04	4.96E+02	9.87E+03	4.65E+06	3.57E+04	3.87E+03
SILICON DAMAGE 1 MEV EQUIVALENT N/CM2/S/KW	1.03E+06	6.70E+05	6.21E+07	2.89E+07	1.63E+06	1.71E+04	9.01E+05	4.92E+08	8.18E+06	1.77E+05
NEUTRON DOSE RAD/S/KW	4.04E-03	2.77E-03	2.16E-01	1.85E-01	6.95E-03	6.22E-05	3.59E-03	3.13E+00	5.77E-02	6.58E-04
GAMMA DOSE RAD/S/KW	1.86E-03	5.90E-04	3.83E-04	1.84E-02	3.60E-03	7.74E-04	6.99E-04	1.03E+00	1.26E-02	1.29E-03
NEUTRON DOSE REM/S/KW	2.82E-02	1.81E-02	1.80E+00	5.66E-01	4.29E-02	4.75E-04	2.46E-02	9.51E+00	1.44E-01	4.90E-03
TOTAL DOSE RAD/S/KW	5.90E-03	3.36E-03	2.17E-01	2.04E-01	1.05E-02	8.36E-04	4.29E-03	4.21E+00	7.03E-02	1.95E-03
TOTAL DOSE REM/S/KW	3.01E-02	1.86E-02	1.80E+00	5.85E-01	4.65E-02	1.25E-03	2.53E-02	1.05E+01	1.56E-01	6.19E-03
TOTAL NEUTRON FLUX N/CM2/S/KW	3.58E+06	2.86E+06	1.81E+08	2.66E+08	6.99E+06	4.49E+04	3.36E+06	4.56E+09	8.74E+07	5.18E+05
NEUTRON FLUX >1 MEV N/CM2/S/KW	3.67E+05	1.37E+05	1.02E+07	3.95E+06	5.22E+05	7.67E+03	2.70E+05	6.69E+07	6.41E+05	7.27E+04

Table II.3.33. Total Response Per Kilowatt For ANISN (1-D) Results.

RESPONSE	CASE 1	CASE 2	CASE 3	CASE 4	CASE 5	CASE 6	CASE 7	CASE 8	CASE 9	CASE 10
SULFUR ACTIVATION ACTS/CC-S/ATOM/BN-CM/KW	5.72E+06	1.22E+06	3.99E+05	3.38E+06	5.21E+06	1.66E+05	3.41E+06	7.73E+07	4.96E+05	1.28E+06
SILICON DAMAGE 1 MEV EQUIVALENT N/CM2/S/KW	9.20E+07	5.52E+07	1.65E+08	1.21E+08	8.63E+07	1.75E+06	7.59E+07	2.05E+09	2.67E+07	1.63E+07
NEUTRON DOSE RAD/S/KW	2.95E-01	1.76E-01	5.63E-01	5.78E-01	2.96E-01	5.50E-03	2.43E-01	9.86E+00	1.51E-01	5.15E-02
GAMMA DOSE RAD/S/KW	4.83E-01	1.98E-03	8.60E-04	9.66E-02	4.57E-01	2.09E-01	3.60E-02	8.48E+00	6.42E-02	3.67E-01
NEUTRON DOSE REM/S/KW	2.58E+00	1.64E+00	4.81E+00	2.91E+00	2.36E+00	4.58E-02	2.18E+00	4.85E+01	5.78E-01	4.41E-01
TOTAL DOSE RAD/S/KW	7.78E-01	1.77E-01	5.65E-01	6.75E-01	7.52E-01	2.14E-01	2.78E-01	1.83E+01	2.15E-01	4.19E-01
TOTAL DOSE REM/S/KW	3.06E+00	1.64E+00	4.82E+00	3.00E+00	2.82E+00	2.54E-01	2.23E+00	5.70E+01	6.41E-01	8.98E-01
TOTAL NEUTRON FLUX N/CM2/S/KW	1.15E+08	8.40E+07	4.42E+08	6.33E+08	1.53E+08	1.60E+06	1.01E+08	1.06E+10	1.95E+08	1.69E+07
NEUTRON FLUX >1 MEV N/CM2/S/KW	5.17E+07	2.40E+07	3.16E+07	4.02E+07	4.65E+07	1.03E+06	4.01E+07	7.33E+08	6.50E+06	9.55E+06

4. THREE-DIMENSIONAL CALCULATIONS

4.1. Three-Dimensional Models

Three-dimensional calculations were performed for eight of the ten reactor/room configurations described in chapter II.1. On the basis of these eight calculations, it was decided that no new information would be gained by doing the 3-D calculations for the remaining two cases. See Tables II.1.1 and II.1.2 for descriptions of the cases and location of the detectors.

In the case of the MORSE calculations, the modeling of the physical configuration includes all the important components in their proper location and shape. Therefore, the drawings of the experimental arragements contained in Volume I of this report serve equally well to display the calculational configuration for the MORSE runs.

Since the geometric modeling is fairly exact, the major concerns in MORSE models are associated more with the source description, transport approximations, and variance reduction biasing techniques. The source for these MORSE calculations was the output from an ANISN run. Past work[12,13] has shown that the coupling of discrete ordinates and Monte Carlo codes can lead to very efficient uses of the advantages of each technique. In this case, ANISN was run from the core to the outside surface of the reactor tank and shield. At this point a boundary leakage tape was written which is then used as a source for the MORSE runs. This approach allows use of the flexible, but time consuming, 3-D modeling capability of MORSE in the room itself (where it is needed) without having to recalculate the core region every time. Thus, when the room configuration changes, only the part of the calculation which has been changed has to be rerun. When the core configuration is changed, as in the case of moving the core back 12 inches, or moving the core to ER2, a new ANISN leakage source must be prepared. By noting the cases which were considered, one can see that only three leakage source were needed: one for ER1 with the core all the way in, one for ER2 with the core all the way in, and one for ER1 with the core moved back 12 inches. As will be seen later, the 1-D and 3-D results agree for ER1 free field with the core moved all the way in and with it moved back 12 inches, so it was not necessary to do a 3-D calculation of the free field in ER1 with the core moved back 5 inches. If it had been necessary, then another leakage source would have been generated.

With the leakage spectrum and angular distribution at the surface of the reactor tank supplied by the ANISN runs, a spatial distribution must be applied to allow the selection of starting positions for the source neutrons. This was derived from information supplied by AFRRI personnel[11]. Sulfur buttons were placed on the face of the reactor tank and irradiated. Use of the $^{32}S(n,p)$ reaction allows the calculation of the fluence of neutrons above 3 Mev at the position of each sulfur button. The buttons were placed on a vertical line on the part of the tank which extends the farthest into the room (the measurement was performed in ER1 with the core moved all the way in) and on a horizontal line along the circumference of the tank at the core midplane. The buttons were placed one inch apart along each line. Figure II.4.1 shows the sulfur fluence as a function of axial and azimuthal position on the tank face. These distributions were used to select, in the standard Monte Carlo fashion, the starting positions of the source neutrons. Due to lack of any data for ER2 and other positions of the core for ER1, this same spatial distribution was used for all the MORSE calculations. This assumption is not expected to adversely affect the results.

Several transport approximations were made which considerably enhanced the running time of the MORSE calculations without impairing the accuracy of the results. All of these approximations are the result of the presence of the wood on the walls, ceiling, and floor of the exposure rooms. The problem which the wood presents is that neutrons tend to scatter in the wood without being absorbed or contributing to the detector response. Neutrons will enter the wood, become thermalized, and then bounce around for a long time before stopping by absorption or escaping from the system. This problem was overcome by taking advantage of the presence of the gadolinium paint on the walls and ceiling. This paint is fairly thick to thermal neutrons (several mean free paths). If a neutron becomes thermalized in the wood behind the paint, it has very little chance of penetrating the paint and re-entering the room. Therefore, once a neutron becomes thermalized in the walls or the ceiling it is killed and the history is terminated. The floor does not have any gadolinium paint on it and in most cases the floor is only four feet from the detector location, so neutrons are allowed to scatter in the floor until they are absorbed, re-enter the room, or escape the system.

This approximation should not affect the neutron spectra significantly, but it will have an effect on the gamma-ray spectra. This gamma-ray effect comes from the fact that some of the gamma rays which are produced in the wood and

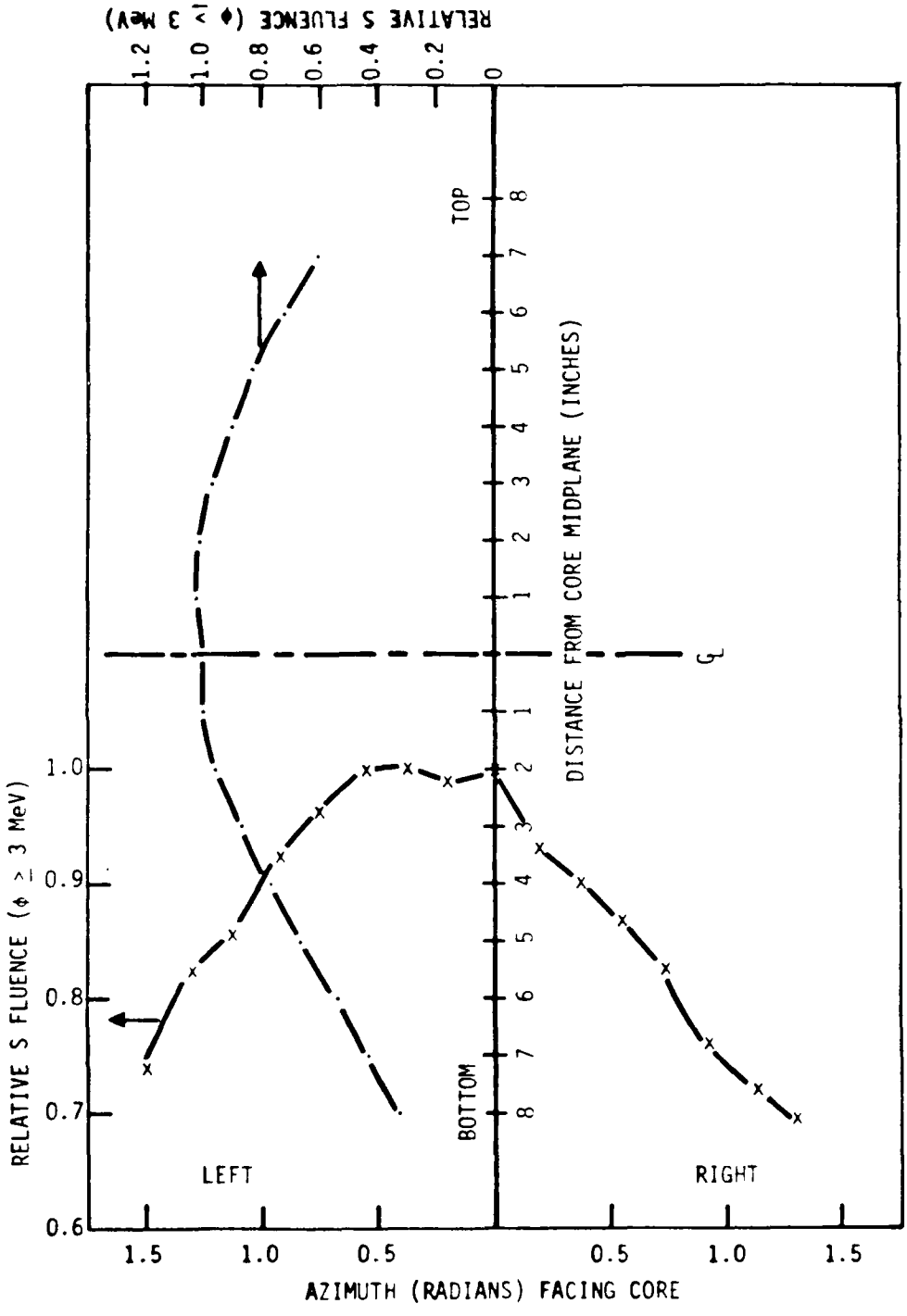

Figure II.4.1. Axial and Azimuthal Dependence of Leakage on the Reactor Tank Surface.

gadolinium paint come from the absorption of thermal neutrons. This fact resulted in the decision not to calculate the gamma-ray spectra in three dimensions. Note that this limitation does not apply to the one-dimensionl gamma-ray results.

Finally, several variance reduction techniques were applied including Russian roulette, mild path length stretching to the center of the room, and splitting. These techniques are not approximations but should be mentioned for completeness. They serve to reduce the statistical uncertainty associated with the results. As can be seen from the 1-D results the spectra fall off rapidly at high energy. This rapid falloff induces a scarcity of source neutrons in the high energy region. As a result, the statistical uncertainty of this part of the spectrum can be become intolerable. Source energy biasing was tried to the point of overbiasing, but the problem persisted. The resolution became apparent when the good agreement between the 1-D and 3-D results was observed. This agreement, plus the fact that high energy neutrons are less affected by complex geometries than the low energy neutrons due to a smaller scattering cross section, resulted in the idea of slicing the 1-D and 3-D results together. Thus, 1-D results will be shown for energies greater than 4 Mev and 3-D results will be shown for energies less than 4 Mev. The smoothness of the curves (independently normalized) in the 4 Mev region further strengthens the validity of this approach. For completeness, tabulated spectra and responses will be reported for the unspliced 3-D spectra and then plots of the spliced spectra follow.

4.2. Three-Dimension Results

The results of the unspliced MORSE calculations are shown in Tables II.4.1 through II.4.8. These tables show tabulated front, back, and total spectra. Tables II.4.9 through II.4.11 show front, back, and total components of the same nine integral responses calculated for the 1-D runs. These quantities are useful measures of comparing the 1-D and 3-D results. The other major mode of comparison is, of course, the spectral shapes. Due to the dirth of high energy neutrons mentioned earlier, the spliced 1-D/3-D spectra represent the best 3-D spectra and should be used to compare 1-D and 3-D results. These spectra are presented in Figures II.4.2 through II.4.25 and Tables II.4.12 through II.4.19.

Table II.4.1. 3-D Neutron Flux Per Unit Lethargy Per Kilowatt.

ERI FREE FIELD

GROUP	ENERGY (EV)	FRONT	BACK	TOTAL
1	1.960E+07	0.00E+00 0.00	0.00E+00 0.00	0.00E+00 0.00
2	1.690E+07	0.00E+00 0.00	0.00E+00 0.00	0.00E+00 0.00
3	1.490E+07	0.00E+00 0.00	0.00E+00 0.00	0.00E+00 0.00
4	1.420E+07	0.00E+00 0.00	0.00E+00 0.00	0.00E+00 0.00
5	1.380E+07	0.00E+00 0.00	0.00E+00 0.00	0.00E+00 0.00
6	1.280E+07	0.00E+00 0.00	0.00E+00 0.00	0.00E+00 0.00
7	1.220E+07	2.10E+04 1.00	0.00E+00 0.00	2.10E+04 1.00
8	1.110E+07	2.89E+04 0.93	0.00E+00 0.00	2.89E+04 0.93
9	1.000E+07	5.65E+06 0.59	0.00E+00 0.00	5.65E+06 0.59
10	9.050E+06	3.01E+06 0.64	0.00E+00 0.00	3.01E+06 0.64
11	8.190E+06	1.50E+07 0.33	0.00E+00 0.00	1.50E+07 0.33
12	7.410E+06	1.37E+07 0.28	0.00E+00 0.00	1.37E+07 0.28
13	6.380E+06	1.99E+07 0.16	0.00E+00 0.00	1.99E+07 0.16
14	4.970E+06	5.15E+07 0.24	0.00E+00 0.00	5.15E+07 0.24
15	4.720E+06	3.56E+07 0.20	1.49E+04 1.00	3.56E+07 0.20
16	4.070E+06	4.78E+07 0.11	6.52E+04 0.69	4.79E+07 0.11
17	3.010E+06	5.37E+07 0.10	3.39E+05 0.29	5.41E+07 0.10
18	2.390E+06	3.80E+07 0.29	4.43E+05 0.30	3.84E+07 0.29
19	2.310E+06	5.36E+07 0.10	4.97E+05 0.34	5.41E+07 0.10

Table II.4.1. 3-D Neutron Flux Per Unit Lethargy Per Kilowatt (continued).

ER1 FREE FIELD

GROUP	ENERGY (EV)	FRONT	BACK	TOTAL
20	1.830E+06	3.47E+07 0.07	2.68E+05 0.12	3.49E+07 0.07
21	1.110E+06	2.45E+07 0.07	3.64E+05 0.11	2.49E+07 0.07
22	5.500E+05	1.12E+07 0.06	2.89E+05 0.10	1.15E+07 0.06
23	1.580E+05	8.97E+06 0.13	2.11E+05 0.15	9.18E+06 0.13	
24	1.110E+05	5.68E+06 0.11	2.18E+05 0.17	5.90E+06 0.10
25	5.250E+04	4.40E+06 0.13	[illegible]E+05 0.15	4.55E+06 0.12
26	2.480E+04	5.57E+06 0.28	1.03E+05 0.49	5.68E+06 0.28
27	2.190E+04	5.01E+06 0.13	1.62E+05 0.17	5.17E+06 0.13
28	1.030E+04	4.55E+06 0.11	1.58E+05 0.12	4.70E+06 0.11
29	3.350E+03	3.82E+06 0.15	1.89E+05 0.25	4.01E+06 0.15
30	1.230E+03	3.93E+06 0.15	1.77E+05 0.20	4.11E+06 0.14
31	5.830E+02	4.16E+06 0.10	1.67E+05 0.10	4.33E+06 0.09
32	1.010E+02	3.18E+06 0.15	1.80E+05 0.12	3.36E+06 0.14
33	2.900E+01	2.87E+06 0.18	1.99E+05 0.16	3.06E+06 0.17
34	1.070E+01	1.39E+06 0.23	1.72E+05 0.12	1.56E+06 0.20
35	3.060E+00	1.11E+06 0.36	1.38E+05 0.13	1.25E+06 0.32
36	1.130E+00	7.36E+05 0.45	1.57E+05 0.16	8.93E+05 0.37
37	4.140E-01	8.78E+04 0.48	9.83E+04 0.33	1.86E+05 0.28

Table II.4.2. 3-D Neutron Flux Per Unit Lethargy Per Kilowatt.

ER1 WITH 6" PB

GROUP	ENERGY (EV)	FRONT	BACK	TOTAL
1	1.960E+07	0.00E+00 0.00	0.00E+00 0.00	0.00E+00 0.00
2	1.690E+07	0.00E+00 0.00	0.00E+00 0.00	0.00E+00 0.00
3	1.490E+07	0.00E+00 0.00	0.00E+00 0.00	0.00E+00 0.00
4	1.420E+07	0.00E+00 0.00	0.00E+00 0.00	0.00E+00 0.00
5	1.380E+07	0.00E+00 0.00	0.00E+00 0.00	0.00E+00 0.00
6	1.280E+07	9.64E+01 1.00	0.00E+00 0.00	9.64E+01 1.00
7	1.220E+07	3.02E+05 0.61	0.00E+00 0.00	3.02E+05 0.61
8	1.110E+07	1.11E+05 0.87	0.00E+00 0.00	1.11E+05 0.87
9	1.000E+07	3.61E+05 0.65	0.00E+00 0.00	3.61E+05 0.65
10	9.050E+06	1.95E+06 0.63	0.00E+00 0.00	1.95E+06 0.63
11	8.190E+06	9.39E+05 0.64	0.00E+00 0.00	9.39E+05 0.64
12	7.410E+06	4.29E+06 0.44	0.00E+00 0.00	4.29E+06 0.44
13	6.380E+06	3.35E+06 0.27	0.00E+00 0.00	3.35E+06 0.27
14	4.970E+06	4.33E+06 0.47	0.00E+00 0.00	4.33E+06 0.47
15	4.720E+06	7.71E+06 0.36	4.64E+03 1.00	7.72E+06 0.36
16	4.070E+06	6.54E+06 0.12	7.63E+03 0.77	6.55E+06 0.12
17	3.010E+06	1.16E+07 0.13	7.57E+04 0.22	1.17E+07 0.13
18	2.390E+06	2.21E+07 0.36	3.21E+04 0.75	2.21E+07 0.36
19	2.310E+06	1.70E+07 0.09	5.23E+04 0.23	1.70E+07 0.09

Table II.4.2. 3-D Neutron Flux Per Unit Lethargy Per Kilowatt (continued).

ER1 WITH 6" PB

GROUP	ENERGY (EV)	FRONT	BACK	TOTAL
20	1.830E+06	2.33E+07 0.08	1.20E+05 0.12	2.34E+07 0.08
21	1.110E+06	2.22E+07 0.08	2.18E+05 0.09	2.24E+07 0.08
22	5.500E+05	9.81E+06 0.09	1.72E+05 0.10	9.98E+06 0.09
23	1.580E+05	6.53E+06 0.20	1.18E+05 0.15	6.65E+06 0.19
24	1.110E+05	4.82E+06 0.26	2.21E+05 0.50	5.04E+06 0.25
25	5.250E+04	2.96E+06 0.27	1.07E+05 0.13	3.07E+06 0.26
26	2.480E+04	1.54E+06 0.38	1.15E+05 0.21	1.65E+06 0.36
27	2.190E+04	1.61E+06 0.23	6.93E+04 0.12	1.68E+06 0.22
28	1.030E+04	2.13E+06 0.22	1.12E+05 0.16	2.24E+06 0.20
29	3.350E+03	9.68E+05 0.25	9.49E+04 0.12	1.06E+06 0.23
30	1.230E+03	1.52E+06 0.32	1.06E+05 0.20	1.63E+06 0.30
31	5.830E+02	1.10E+06 0.28	9.59E+04 0.10	1.20E+06 0.26
32	1.010E+02	1.51E+06 0.30	8.51E+04 0.12	1.60E+06 0.28
33	2.900E+01	8.92E+05 0.25	8.96E+04 0.12	9.82E+05 0.22
34	1.070E+01	7.71E+05 0.38	8.49E+04 0.09	8.56E+05 0.34
35	3.060E+00	5.55E+05 0.71	7.99E+04 0.14	6.35E+05 0.62
36	1.130E+00	2.89E+05 0.46	7.78E+04 0.12	3.67E+05 0.36
37	4.140E-01	8.09E+04 0.35	2.15E+04 0.19	8.25E+04 0.22

Table II.4.3. 3-D Neutron Flux Per Unit Lethargy Per Kilowatt.

ER1 WITH 6" PB AND CAVE

GROUP	ENERGY (EV)	FRONT	BACK	TOTAL
1	1.960E+07	0.00E+00 0.00	0.00E+00 0.00	0.00E+00 0.00
2	1.690E+07	0.00E+00 0.00	0.00E+00 0.00	0.00E+00 0.00
3	1.490E+07	0.00E+00 0.00	0.00E+00 0.00	0.00E+00 0.00
4	1.420E+07	0.00E+00 0.00	0.00E+00 0.00	0.00E+00 0.00
5	1.380E+07	0.00E+00 0.00	0.00E+00 0.00	0.00E+00 0.00
6	1.280E+07	0.00E+00 0.00	0.00E+00 0.00	0.90E+00 0.00
7	1.220E+07	1.79E+05 0.95	0.00E+00 0.00	1.79E+05 0.95
8	1.110E+07	2.09E+05 0.67	0.00E+00 0.00	2.09E+05 0.67
9	1.000E+07	2.85E+05 0.82	0.00E+00 0.00	2.85E+05 0.82
10	9.050E+06	1.85E+06 0.66	0.00E+00 0.00	1.85E+06 0.66
11	8.190E+06	1.33E+06 0.74	0.00E+00 0.00	1.33E+06 0.74
12	7.410E+06	5.74E+06 0.73	2.54E+05 1.00	6.00E+06 0.70
13	6.380E+06	3.03E+06 0.26	2.44E+02 1.00	3.03E+06 0.26
14	4.970E+06	5.27E+06 0.56	5.83E+03 0.66	5.28E+06 0.56
15	4.720E+06	2.49E+06 0.46	2.12E+04 0.56	2.51E+06 0.45
16	4.070E+06	7.28E+06 0.20	5.48E+05 0.41	7.83E+06 0.19
17	3.010E+06	1.18E+07 0.16	1.66E+06 0.48	1.35E+07 0.16
18	2.390E+06	1.02E+07 0.39	2.86E+06 0.93	1.30E+07 0.36
19	2.310E+06	1.95E+07 0.13	1.58E+07 0.75	3.53E+07 0.34

Table II.4.3. 3-D Neutron Flux Per Unit Lethargy Per Kilowatt (continued).

ER1 WITH 6" PB AND CAVE

GROUP	ENERGY (EV)	FRONT	BACK	TOTAL
20	1.830E+06	2.44E+07 0.11	2.68E+06 0.49	2.71E+07 0.11
21	1.110E+06	2.84E+07 0.11	6.82E+06 0.34	3.52E+07 0.11
22	5.500E+05	1.85E+07 0.14	3.40E+06 0.26	2.19E+07 0.13
23	1.580E+05	9.45E+06 0.22	2.61E+06 0.52	1.21E+07 0.21
24	1.110E+05	3.83E+06 0.24	1.38E+06 0.56	5.21E+06 0.23
25	5.250E+04	1.10E+06 0.21	5.82E+05 0.74	1.68E+06 0.29
26	2.480E+04	5.44E+06 0.77	8.18E+05 0.82	6.26E+06 0.68
27	2.190E+04	1.92E+06 0.30	8.65E+05 0.55	2.78E+06 0.27
28	1.030E+04	1.19E+06 0.21	3.98E+05 0.45	1.59E+06 0.19
29	3.350E+03	2.18E+06 0.62	2.22E+06 0.72	4.40E+06 0.48
30	1.230E+03	1.23E+06 0.42	2.50E+05 0.78	1.48E+06 0.37
31	5.830E+02	1.14E+06 0.28	3.77E+06 0.79	4.91E+06 0.61
32	1.010E+02	1.87E+06 0.58	8.48E+06 0.97	1.03E+07 0.80
33	2.900E+01	1.81E+06 0.39	8.19E+05 0.95	2.13E+06 0.36
34	1.070E+01	1.41E+06 0.35	2.75E+05 0.89	1.69E+06 0.33
35	3.060E+00	6.01E+05 0.60	3.77E+05 0.68	9.78E+05 0.45
36	1.130E+00	1.15E+06 0.60	1.71E+06 0.95	2.86E+06 0.62
37	4.140E-01	5.25E+04 0.81	7.90E+03 0.61	6.04E+04 0.71

Table II.4.4. 3-D Neutron Flux Per Unit Lethargy Per Kilowatt.

ER1 WITH 2" PB AND EXERCISE WHEEL

GROUP	ENERGY (EV)	FRONT	BACK	TOTAL
1	1.900E+07	0.00E+00 0.00	0.00E+00 0.00	0.00E+00 0.00
2	1.690E+07	0.00E+00 0.00	0.00E+00 0.00	0.00E+00 0.00
3	1.490E+07	0.00E+00 0.00	0.00E+00 0.00	0.00E+00 0.00
4	1.420E+07	0.00E+00 0.00	0.00E+00 0.00	0.00E+00 0.00
5	1.380E+07	2.99E+04 0.65	0.00E+00 0.00	2.99E+04 0.65
6	1.280E+07	0.00E+00 0.00	0.00E+00 0.00	0.00E+00 0.00
7	1.220E+07	2.23E+05 1.00	0.00E+00 0.00	2.23E+05 1.00
8	1.110E+07	6.27E+05 0.64	0.00E+00 0.00	6.27E+05 0.64
9	1.000E+07	1.07E+06 0.62	0.00E+00 0.00	1.07E+06 0.62
10	9.050E+06	8.60E+06 0.49	0.00E+00 0.00	8.60E+06 0.49
11	8.190E+06	2.89E+06 0.36	2.00E+05 0.96	3.09E+06 0.34
12	7.410E+06	1.10E+07 0.25	6.37E+05 1.00	1.16E+07 0.25
13	6.380E+06	1.18E+07 0.20	1.02E+06 0.98	1.29E+07 0.20
14	4.970E+06	2.73E+07 0.55	0.00E+00 0.00	2.73E+07 0.55
15	4.720E+06	3.57E+07 0.25	1.15E+05 1.00	3.58E+07 0.25
16	4.070E+06	2.62E+07 0.15	1.35E+06 0.60	2.75E+07 0.14
17	3.010E+06	3.27E+07 0.12	7.54E+05 0.60	3.34E+07 0.11
18	2.390E+06	4.53E+07 0.31	2.24E+06 0.66	4.75E+07 0.30
19	2.310E+06	3.41E+07 0.12	2.03E+04 1.00	3.41E+07 0.12

Table II.4.4. 3-D Neutron Flux Per Unit Lethargy Per Kilowatt (continued).

ER1 WITH 2" PB AND EXERCISE WHEEL

GROUP	ENERGY (EV)	FRONT	BACK	TOTAL
20	1.830E+06	3.05E+07 0.08	3.44E+06 0.23	3.39E+07 0.08
21	1.110E+06	2.62E+07 0.10	3.99E+06 0.36	3.01E+07 0.10
22	5.500E+05	1.32E+07 0.12	3.07E+06 0.26	1.62E+07 0.11
23	1.580E+05	7.82E+06 0.25	3.08E+06 0.48	1.09E+07 0.23
24	1.110E+05	5.08E+06 0.18	2.02E+06 0.33	7.10E+06 0.16
25	5.250E+04	5.01E+06 0.34	9.17E+05 0.35	5.93E+06 0.30
26	2.480E+04	3.66E+06 0.35	1.16E+06 1.00	4.82E+06 0.86
27	2.190E+04	2.53E+06 0.19	1.14E+06 0.30	3.67E+06 0.16
28	1.030E+04	3.70E+06 0.27	1.61E+06 0.42	5.31E+06 0.23
29	3.350E+03	2.31E+06 0.32	1.19E+06 0.36	3.50E+06 0.24
30	1.230E+03	3.48E+06 0.27	2.41E+06 0.48	5.89E+06 0.25
31	5.830E+02	2.84E+06 0.15	1.43E+06 0.38	4.26E+06 0.16
32	1.010E+02	2.31E+06 0.20	1.18E+06 0.31	3.49E+06 0.17
33	2.900E+01	3.23E+06 0.30	9.07E+05 0.30	4.13E+06 0.24
34	1.070E+01	2.39E+06 0.19	1.15E+06 0.39	3.54E+06 0.18
35	3.060E+00	2.00E+06 0.41	8.26E+05 0.29	2.83E+06 0.30
36	1.130E+00	2.43E+06 0.57	9.99E+05 0.37	3.43E+06 0.42
37	4.140E-01	2.49E+06 0.81	2.71E+06 0.34	5.20E+06 0.23

Table II.4.5. 3-D Neutron Flux Per Unit Lethargy Per Kilowatt.

ER2 FREE FIELD

GROUP	ENERGY (EV)	FRONT	BACK	TOTAL
1	1.960E+07	0.00E+00 0.00	0.00E+00 0.00	0.00E+00 0.00
2	1.690E+07	0.00E+00 0.00	0.00E+00 0.00	0.00E+00 0.00
3	1.490E+07	0.00E+00 0.00	0.00E+00 0.00	0.00E+00 0.00
4	1.420E+07	0.00E+00 0.00	0.00E+00 0.00	0.00E+00 0.00
5	1.380E+07	0.00E+00 0.00	0.00E+00 0.00	0.00E+00 0.00
6	1.280E+07	0.00E+00 0.00	0.00E+00 0.00	0.00E+00 0.00
7	1.220E+07	1.23E+06 0.86	0.00E+00 0.00	1.23E+06 0.86
8	1.110E+07	2.29E+04 1.00	5.19E+03 1.00	2.81E+04 0.84
9	1.000E+07	8.14E+06 0.70	0.00E+00 0.00	8.14E+06 0.70
10	9.050E+06	8.42E+06 0.55	0.00E+00 0.00	8.42E+06 0.55
11	8.190E+06	1.58E+07 0.56	0.00E+00 0.00	1.58E+07 0.56
12	7.410E+06	1.08E+07 0.32	0.00E+00 0.00	1.08E+07 0.32
13	6.380E+06	2.04E+07 0.20	0.00E+00 0.00	2.04E+07 0.20
14	4.970E+06	3.42E+07 0.33	0.00E+00 0.00	3.42E+07 0.33
15	4.720E+06	3.15E+07 0.26	0.00E+00 0.00	3.15E+07 0.26
16	4.070E+06	4.16E+07 0.12	7.79E+04 0.86	4.17E+07 0.12
17	3.010E+06	4.69E+07 0.15	4.76E+05 0.20	4.73E+07 0.15
18	2.390E+06	4.99E+07 0.42	2.72E+05 0.61	5.02E+07 0.42
19	2.310E+06	4.64E+07 0.12	3.58E+05 0.23	4.67E+07 0.12

Table II.4.5. 3-D Neutron Flux Per Unit Lethargy Per Kilowatt (continued).

ER2 FREE FIELD

GROUP	ENERGY (EV)	FRONT	BACK	TOTAL
20	1.830E+06	4.19E+07 0.10	4.80E+05 0.16	4.24E+07 0.09
21	1.110E+06	2.82E+07 0.08	7.26E+05 0.12	2.89E+07 0.08
22	5.500E+05	9.71E+06 0.07	3.65E+05 0.09	1.01E+07 0.07
23	1.580E+05	7.15E+06 0.19	3.65E+05 0.19	7.52E+06 0.18
24	1.110E+05	7.81E+06 0.12	3.82E+05 0.29	8.19E+06 0.12
25	5.250E+04	3.77E+06 0.16	2.61E+05 0.16	4.03E+06 0.15
26	2.480E+04	7.23E+06 0.29	1.97E+05 0.31	7.43E+06 0.28
27	2.190E+04	5.20E+06 0.14	2.31E+05 0.20	5.44E+06 0.14
28	1.030E+04	3.80E+06 0.14	3.90E+05 0.19	4.19E+06 0.13
29	3.350E+03	3.49E+06 0.16	2.98E+05 0.14	3.79E+06 0.15
30	1.230E+03	3.27E+06 0.22	7.42E+05 0.67	4.01E+06 0.22
31	5.830E+02	4.13E+06 0.10	2.21E+05 0.10	4.35E+06 0.10
32	1.010E+02	3.44E+06 0.12	2.47E+05 0.11	3.69E+06 0.11
33	2.900E+01	3.64E+06 0.17	2.76E+05 0.17	3.92E+06 0.16
34	1.070E+01	4.22E+06 0.13	3.64E+05 0.16	4.59E+06 0.12
35	3.060E+00	4.29E+06 0.15	3.34E+05 0.15	4.62E+06 0.14
36	1.130E+00	4.26E+06 0.12	2.83E+05 0.12	4.54E+06 0.11
37	4.140E-01	4.14E+06 0.07	2.01E+05 0.13	4.34E+06 0.07

Table II.4.6. 3-D Neutron Flux Per Unit Lethargy Per Kilowatt.

ERI FREE FIELD WITH 12" WATER

GROUP	ENERGY (EV)	FRONT	BACK	TOTAL
1	1.960E+07	0.00E+00 0.00	0.00E+00 0.00	0.00E+00 0.00
2	1.690E+07	0.00E+00 0.00	0.00E+00 0.00	0.00E+00 0.00
3	1.490E+07	7.53E+03 1.00	0.00E+00 0.00	7.53E+03 1.00
4	1.420E+07	0.00E+00 0.00	0.00E+00 0.00	0.00E+00 0.00
5	1.380E+07	2.18E+02 1.00	0.00E+00 0.00	2.18E+02 1.00
6	1.280E+07	0.00E+00 0.00	0.00E+00 0.00	0.00E+00 0.00
7	1.220E+07	1.58E+03 0.64	0.00E+00 0.00	1.58E+03 0.64
8	1.110E+07	8.51E+04 0.51	0.00E+00 0.00	8.51E+04 0.51
9	1.000E+07	2.40E+05 0.42	0.00E+00 0.00	2.40E+05 0.42
10	9.050E+06	1.78E+05 0.40	0.00E+00 0.00	1.78E+05 0.40
11	8.190E+06	1.92E+05 0.34	0.00E+00 0.00	1.92E+05 0.34
12	7.410E+06	3.98E+05 0.19	0.00E+00 0.00	3.98E+05 0.19
13	6.380E+06	4.46E+05 0.13	0.00E+00 0.00	4.46E+05 0.13
14	4.970E+06	1.69E+05 0.36	0.00E+00 0.00	1.69E+05 0.36
15	4.720E+06	3.16E+05 0.18.	4.04E+02 0.79	3.16E+05 0.18
16	4.070E+06	2.11E+05 0.11	2.07E+03 0.57	2.14E+05 0.11
17	3.010E+06	3.09E+05 0.10	2.23E+03 0.14	3.12E+05 0.10
18	2.390E+06	4.80E+05 0.25	2.34E+03 0.30	4.82E+05 0.24
19	2.310E+06	2.19E+05 0.11	1.62E+03 0.14	2.20E+05 0.11

Table II.4.6. 3-D Neutron Flux Per Unit Lethargy Per Kilowatt (continued).

ER1 FREE FIELD WITH 12" WATER

GROUP	ENERGY (EV)	FRONT	BACK	TOTAL
20	1.830E+06	1.18E+05 0.07	1.50E+03 0.09	1.19E+05 0.07
21	1.110E+06	6.33E+04 0.08	1.49E+03 0.08	6.48E+04 0.08
22	5.500E+05	2.52E+04 0.07	9.69E+02 0.08	2.61E+04 0.07
23	1.580E+05	2.50E+04 0.24	7.86E+02 0.16	2.58E+04 0.23
24	1.110E+05	1.45E+04 0.13	5.65E+02 0.13	1.51E+04 0.12
25	5.250E+04	9.62E+03 0.15	5.79E+02 0.18	1.02E+04 0.14
26	2.480E+04	2.27E+04 0.29	1.23E+03 0.32	2.39E+04 0.28
27	2.190E+04	1.06E+04 0.15	3.16E+02 0.14	1.11E+04 0.14
28	1.030E+04	8.19E+03 0.16	6.23E+02 0.17	8.81E+03 0.15
29	3.350E+03	9.84E+03 0.14	5.64E+02 0.15	1.04E+04 0.13
30	1.230E+03	7.02E+03 0.22	6.07E+02 0.15	7.63E+03 0.20
31	5.830E+02	5.85E+03 0.13	4.24E+02 0.15	6.27E+03 0.12
32	1.010E+02	6.71E+03 0.18	9.27E+02 0.28	7.63E+03 0.16
33	2.900E+01	5.39E+03 0.25	5.29E+02 0.15	5.92E+03 0.23
34	1.070E+01	5.42E+03 0.36	5.17E+02 0.16	5.93E+03 0.33
35	3.060E+00	3.06E+03 0.48	4.35E+02 0.14	3.50E+03 0.35
36	1.130E+00	1.46E+03 0.68	4.78E+02 0.15	1.94E+03 0.52
37	4.140E-01	8.99E+01 0.29	1.24E+02 0.26	1.64E+02 0.21

Table II.4.7. 3-D Neutron Flux Per Unit Lethargy Per Kilowatt.

ER1 WITH 2" PB

GROUP	ENERGY (EV)	FRONT	BACK	TOTAL
1	1.960E+07	0.00E+00 0.00	0.00E+00 0.00	0.00E+00 0.00
2	1.690E+07	0.00E+00 0.00	0.00E+00 0.00	0.00E+00 0.00
3	1.490E+07	0.00E+00 0.00	0.00E+00 0.00	0.00E+00 0.00
4	1.420E+07	0.00E+00 0.00	0.00E+00 0.00	0.00E+00 0.00
5	1.380E+07	1.83E+04 1.00	0.00E+00 0.00	1.83E+04 1.00
6	1.280E+07	0.00E+00 0.00	0.00E+00 0.00	0.00E+00 0.00
7	1.220E+07	6.99E+05 0.98	0.00E+00 0.00	6.99E+05 0.98
8	1.110E+07	1.93E+04 0.71	0.00E+00 0.00	1.93E+04 0.71
9	1.000E+07	6.07E+05 0.60	0.00E+00 0.00	6.07E+05 0.60
10	9.050E+06	3.24E+06 0.72	0.00E+00 0.00	3.24E+06 0.72
11	8.190E+06	4.08E+06 0.81	0.00E+00 0.00	4.08E+06 0.81
12	7.410E+06	6.69E+06 0.37	0.00E+00 0.00	6.69E+06 0.37
13	6.380E+06	2.00E+07 0.22	3.03E+03 1.00	2.00E+07 0.22
14	4.970E+06	2.27E+07 0.26	0.00E+00 0.00	2.27E+07 0.26
15	4.720E+06	1.57E+07 0.16	2.56E+03 1.00	1.57E+07 0.16
16	4.070E+06	2.43E+07 0.14	3.55E+04 0.67	2.43E+07 0.14
17	3.010E+06	2.44E+07 0.10	1.01E+05 0.18	2.45E+07 0.10
18	2.390E+06	4.38E+07 0.17	8.96E+04 0.43	4.39E+07 0.17
19	2.310E+06	2.94E+07 0.10	1.09E+05 0.22	2.95E+07 0.10

Table II.4.7. 3-D Neutron Flux Per Unit Lethargy Per Kilowatt (continued).

ER1 WITH 2" PB

GROUP	ENERGY (EV)	FRONT	BACK	TOTAL
20	1.830E+06	3.32E+07 0.07	8.70E+04 0.12	3.33E+07 0.07
21	1.110E+06	2.28E+07 0.06	1.97E+05 0.13	2.30E+07 0.06
22	5.500E+05	9.03E+06 0.07	1.06E+05 0.13	9.14E+06 0.07
23	1.580E+05	5.54E+06 0.15	5.57E+04 0.15	5.60E+06 0.15
24	1.110E+05	3.41E+06 0.16	1.21E+05 0.53	3.53E+06 0.16
25	5.250E+04	3.76E+06 0.19	9.78E+04 0.28	3.85E+06 0.19
26	2.480E+04	2.77E+06 0.21	4.44E+05 0.67	3.22E+06 0.20
27	2.190E+04	2.92E+06 0.16	5.14E+04 0.24	2.97E+06 0.16
28	1.030E+04	2.24E+06 0.14	7.53E+04 0.16	2.32E+06 0.14
29	3.350E+03	2.28E+06 0.22	4.12E+04 0.13	2.32E+06 0.21
30	1.230E+03	1.60E+06 0.18	7.51E+04 0.27	1.67E+06 0.17
31	5.830E+02	2.35E+06 0.15	9.62E+04 0.40	2.45E+06 0.15
32	1.010E+02	1.47E+06 0.20	6.23E+04 0.26	1.53E+06 0.19
33	2.900E+01	1.30E+06 0.18	4.56E+04 0.16	1.35E+06 0.18
34	1.070E+01	7.37E+05 0.22	5.94E+04 0.17	7.97E+05 0.20
35	3.060E+00	6.33E+05 0.33	5.93E+04 0.28	6.92E+05 0.30
36	1.130E+00	5.31E+05 0.31	4.22E+04 0.15	5.73E+05 0.29
37	4.140E-01	6.76E+02 0.41	7.26E+02 0.23	1.40E+03 0.23

Table II.4.8. 3-D Neutron Flux Per Unit Lethargy Per Kilowatt.

ER1 WITH 6" PB AND PHANTOM

GROUP	ENERGY (EV)	FRONT	BACK	TOTAL
1	1.960E+07	0.00E+00 0.00	0.00E+00 0.00	0.00E+00 0.00
2	1.690E+07	0.00E+00 0.00	0.00E+00 0.00	0.00E+00 0.00
3	1.490E+07	0.00E+00 0.00	0.00E+00 0.00	0.00E+00 0.00
4	1.420E+07	2.41E+10 1.00	0.00E+00 0.00	2.41E+10 1.00
5	1.380E+07	0.00E+00 0.00	0.00E+00 0.00	0.00E+00 0.00
6	1.280E+07	0.00E+00 0.00	0.00E+00 0.00	0.00E+00 0.00
7	1.220E+07	0.00E+00 0.00	0.00E+00 0.00	0.00E+00 0.00
8	1.110E+07	1.88E+09 1.00	0.00E+00 0.00	1.88E+09 1.00
9	1.000E+07	0.00E+00 0.00	0.00E+00 0.00	0.00E+00 0.00
10	9.050E+06	0.00E+00 0.00	0.00E+00 0.00	0.00E+00 0.00
11	8.190E+06	9.59E+09 1.00	0.00E+00 0.00	9.59E+09 1.00
12	7.410E+06	4.77E+10 0.31	0.00E+00 0.00	4.77E+10 0.31
13	6.380E+06	5.06E+10 0.27	0.00E+00 0.00	5.06E+10 0.27
14	4.970E+06	5.01E+10 0.52	0.00E+00 0.00	5.01E+10 0.52
15	4.720E+06	6.52E+10 0.28	5.64E+09 1.00	7.08E+10 0.27
16	4.070E+06	1.10E+11 0.16	4.60E+09 0.81	1.15E+11 0.16
17	3.010E+06	1.55E+11 0.18	8.26E+09 0.70	1.63E+11 0.17
18	2.390E+06	2.41E+11 0.29	5.31E+10 0.78	2.95E+11 0.28
19	2.310E+06	2.55E+11 0.14	2.69E+10 0.44	2.82E+11 0.14

Table II.4.8. 3-D Neutron Flux Per Unit Lethargy Per Kilowatt (continued).

ERI WITH 6" PB AND PHANTOM

GROUP	ENERGY (EV)	FRONT	BACK	TOTAL
20	1.830E+06	3.22E+11 0.08	1.90E+10 0.36	3.41E+11 0.08
21	1.110E+06	2.73E+11 0.08	4.00E+10 0.21	3.13E+11 0.07
22	5.500E+05	1.56E+11 0.08	4.22E+10 0.16	1.98E+11 0.07
23	1.500E+05	1.19E+11 0.16	3.32E+10 0.35	1.52E+11 0.16
24	1.110E+05	1.09E+11 0.11	3.08E+10 0.23	1.40E+11 0.10
25	5.250E+04	7.47E+10 0.14	2.70E+10 0.23	1.02E+11 0.12
26	2.480E+04	9.14E+10 0.38	1.53E+10 0.72	1.07E+11 0.34
27	2.190E+04	6.51E+10 0.16	3.32E+10 0.24	9.82E+10 0.13
28	1.030E+04	5.57E+10 0.15	2.83E+10 0.18	8.39E+10 0.12
29	3.350E+03	7.35E+10 0.14	2.91E+10 0.18	1.03E+11 0.11
30	1.230E+03	7.51E+10 0.19	2.29E+10 0.23	9.81E+10 0.16
31	5.830E+02	5.31E+10 0.12	2.89E+10 0.19	8.21E+10 0.10
32	1.010E+02	6.30E+10 0.13	3.35E+10 0.16	9.65E+10 0.10
33	2.900E+01	7.08E+10 0.13	3.54E+10 0.17	1.06E+11 0.10
34	1.070E+01	6.26E+10 0.10	3.05E+10 0.21	9.31E+10 0.10
35	3.060E+00	5.72E+10 0.15	2.17E+10 0.24	7.89E+10 0.13
36	1.130E+00	5.82E+10 0.14	3.99E+10 0.17	9.80E+10 0.11
37	4.140E-01	2.73E+11 0.11	2.54E+11 0.10	5.28E+11 0.08

Table II.4.9. Front Response Per Kilowatt For MORSE (3-D) Results.

RESPONSE	CASE 1	CASE 2	CASE 3	CASE 4	CASE 5	CASE 6	CASE 7	CASE 8	CASE 9	CASE 10
SULFUR ACTIVATION ACTS/CC-S/ATOM/BN-CM/KW	9.56E+06 (.07)	1.81E+06 (.11)	1.67E+06 (.15)	6.40E+06 (.09)	8.86E+06 (.08)	1.12E+05 (.06)	5.31E+06 (.08)	N/A	4.13E+05 (.09)	N/A
SILICON DAMAGE 1 MEV EQUIVALENT N/CM2/S/KW	1.35E+08 (.04)	6.44E+07 (.04)	7.94E+07 (.06)	1.07E+08 (.05)	1.33E+08 (.05)	9.64E+05 (.05)	8.99E+07 (.04)	N/A	6.25E+07 (.07)	N/A
NEUTRON DOSE RAD/S/KW	4.29E-01 (.04)	1.77E-01 (.05)	2.10E-01 (.06)	3.52E-01 (.05)	4.46E-01 (.04)	3.01E-03 (.05)	2.86E-01 (.04)	N/A	8.25E-02 (.04)	N/A
GAMMA DOSE RAD/S/KW	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NEUTRON DOSE REM/S/KW	3.73E+00 (.04)	1.66E+00 (.05)	2.00E+00 (.06)	2.98E+00 (.05)	3.65E+00 (.04)	2.42E-02 (.04)	2.58E+00 (.04)	N/A	4.81E-01 (.03)	N/A
TOTAL DOSE RAD/S/KW	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	8.25E-02 (.04)	N/A
TOTAL DOSE REM/S/KW	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	4.81E-01 (.03)	N/A
TOTAL NEUTRON FLUX N/CM2/S/KW	1.52E+08 (.03)	7.29E+07 (.04)	9.15E+07 (.07)	1.55E+08 (.07)	2.01E+08 (.03)	7.32E+05 (.03)	1.01E+08 (.03)	N/A	8.18E+07 (.07)	N/A
NEUTRON FLUX > 1 MEV N/CM2/S/KW	7.86E+07 (.04)	2.73E+07 (.05)	2.86E+07 (.07)	5.67E+07 (.05)	7.66E+07 (.05)	5.66E+05 (.04)	5.14E+07 (.05)	N/A	6.74E+06 (.05)	N/A

Table II.4.10. Back Response Per Kilowatt For MORSE (3-D) Results.

RESPONSE	CASE 1	CASE 2	CASE 3	CASE 4	CASE 5	CASE 6	CASE 7	CASE 8	CASE 9	CASE 10
SULFUR ACTIVATION ACTS/CC-S/ATOM BN-CM/KW	1.29E+04 (.40)	1.60E+03 (.47)	2.24E+05 (.46)	2.16E+05 (.51)	1.51E+04 (.37)	1.35E+02 (.55)	5.22E+03 (.35)	N/A	2.00E+04 (.41)	N/A
SILICON DAMAGE 1 MEV EQUIVALENT N/CM2/S/KW	1.18E+06 (.08)	1.34E+06 (.05)	3.30E+07 (.31)	1.22E+07 (.15)	1.84E+06 (.07)	5.13E+03 (.10)	4.33E+05 (.07)	N/A	4.31E+07 (.09)	N/A
NEUTRON DOSE RAD/S/KW	4.62E-03 (.07)	2.05E-03 (.06)	5.91E-02 (.27)	5.39E-02 (.16)	7.71E-03 (.06)	1.86E-05 (.10)	1.59E-03 (.07)	N/A	3.92E-02 (.08)	N/A
GAMMA DOSE RAD/S/KW	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NEUTRON DOSE REM/S/KW	3.18E-02 (.08)	1.45E-02 (.06)	4.70E-01 (.20)	3.23E-01 (.16)	4.98E-02 (.07)	1.46E-04 (.10)	1.22E-02 (.07)	N/A	1.10E-01 (.07)	N/A
TOTAL DOSE RAD/S/KW	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3.92E-02 (.08)	N/A
TOTAL DOSE REM/S/KW	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.10E-01 (.07)	N/A
TOTAL NEUTRON FLUX N/CM2/S/KW	4.21E+06 (.09)	1.97E+06 (.07)	4.09E+07 (.31)	5.55E+07 (.21)	7.71E+06 (.07)	1.30E+04 (.07)	1.31E+06 (.08)	N/A	5.81E+07 (.09)	N/A
NEUTRON FLUX > 1 MEV N/CM2/S/KW	4.01E+05 (.14)	1.20E+05 (.08)	6.68E+06 (.50)	3.33E+06 (.22)	5.58E+05 (.11)	2.37E+03 (.16)	1.33E+05 (.10)	N/A	4.97E+05 (.21)	N/A

Table II.4.11. Total Response Per Kilowatt For MORSE (3-D) Results.

RESPONSE	CASE 1	CASE 2	CASE 3	CASE 4	CASE 5	CASE 6	CASE 7	CASE 8	CASE 9	CASE 10
SULFUR ACTIVATION ACTS/CC-S/ATOM/BN-CM/KW	9.57E+06 (.07)	1.81E+06 (.11)	1.90E+06 (.14)	6.61E+06 (.09)	8.88E+06 (.08)	1.12E+05 (.06)	5.31E+06 (.08)	N/A	4.33E+05 (.09)	N/A
SILICON DAMAGE 1 MEV EQUIVALENT N/CM2/S/KW	1.36E+08 (.04)	6.57E+07 (.04)	1.12E+08 (.10)	1.20E+08 (.05)	1.35E+08 (.05)	9.69E+05 (.05)	9.03E+07 (.04)	N/A	1.06E+08 (.06)	N/A
NEUTRON DOSE RAD/S/KW	4.34E-01 (.04)	1.79E-01 (.05)	2.69E-01 (.08)	4.06E-01 (.05)	4.54E-01 (.04)	3.03E-03 (.05)	2.88E-01 (.04)	N/A	1.22E-01 (.04)	N/A
GAMMA DOSE RAD/S/KW	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NEUTRON DOSE REM/S/KW	3.76E+00 (.04)	1.68E+00 (.05)	2.47E+00 (.07)	3.30E+00 (.05)	3.70E+00 (.04)	2.43E-02 (.04)	2.60E+00 (.04)	N/A	5.91E-01 (.03)	N/A
TOTAL DOSE RAD/S/KW	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.22E-01 (.04)	N/A
TOTAL DOSE REM/S/KW	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	5.90E-01 (.03)	N/A
TOTAL NEUTRON FLUX N/CM2/S/KW	1.56E+08 (.03)	7.49E+07 (.04)	1.32E+08 (.11)	2.10E+08 (.08)	2.08E+08 (.03)	7.45E+05 (.03)	1.02E+08 (.03)	N/A	1.40E+08 (.06)	N/A
NEUTRON FLUX >1 MEV N/CM2/S/KW	7.90E+07 (.04)	2.75E+07 (.05)	3.53E+07 (.11)	6.00E+07 (.05)	7.71E+07 (.05)	5.69E+05 (.04)	5.16E+07 (.05)	N/A	7.23E+06 (.05)	N/A

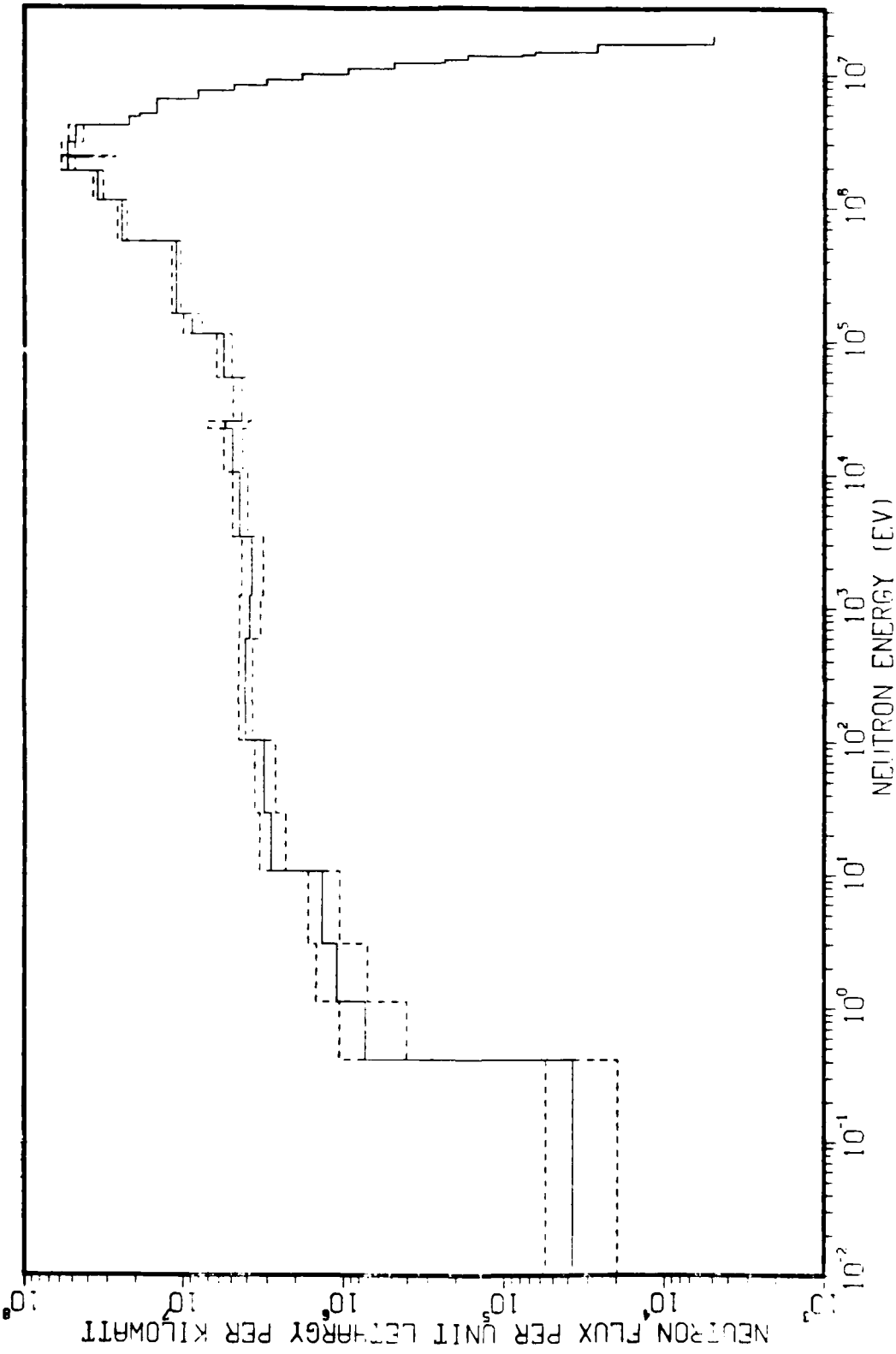

Figure II.4.2. Front Neutron Flux vs Energy ER1 Free Field.

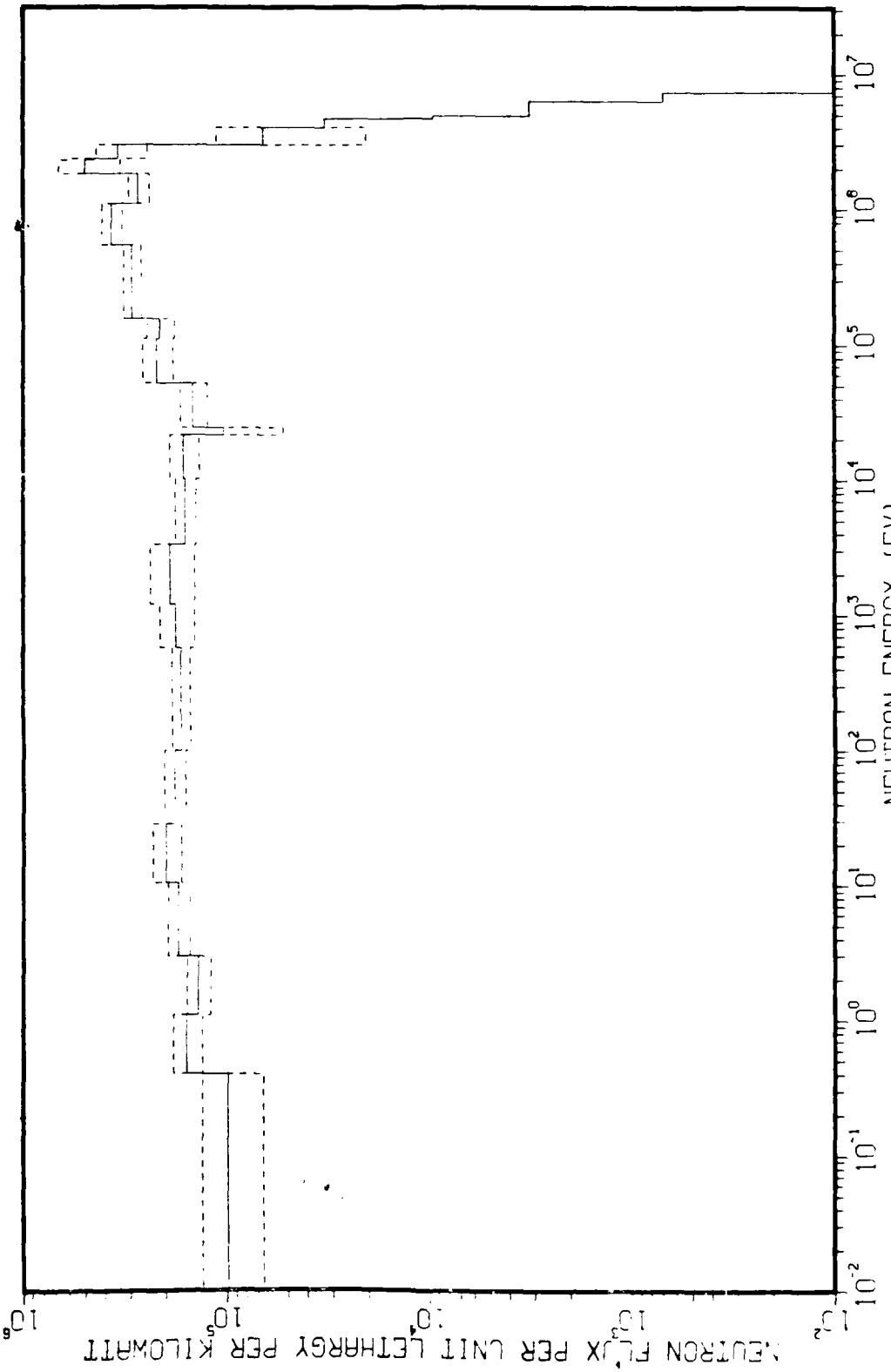

Figure II.4.3. Back Neutron Flux vs Energy ER1 Free Field.

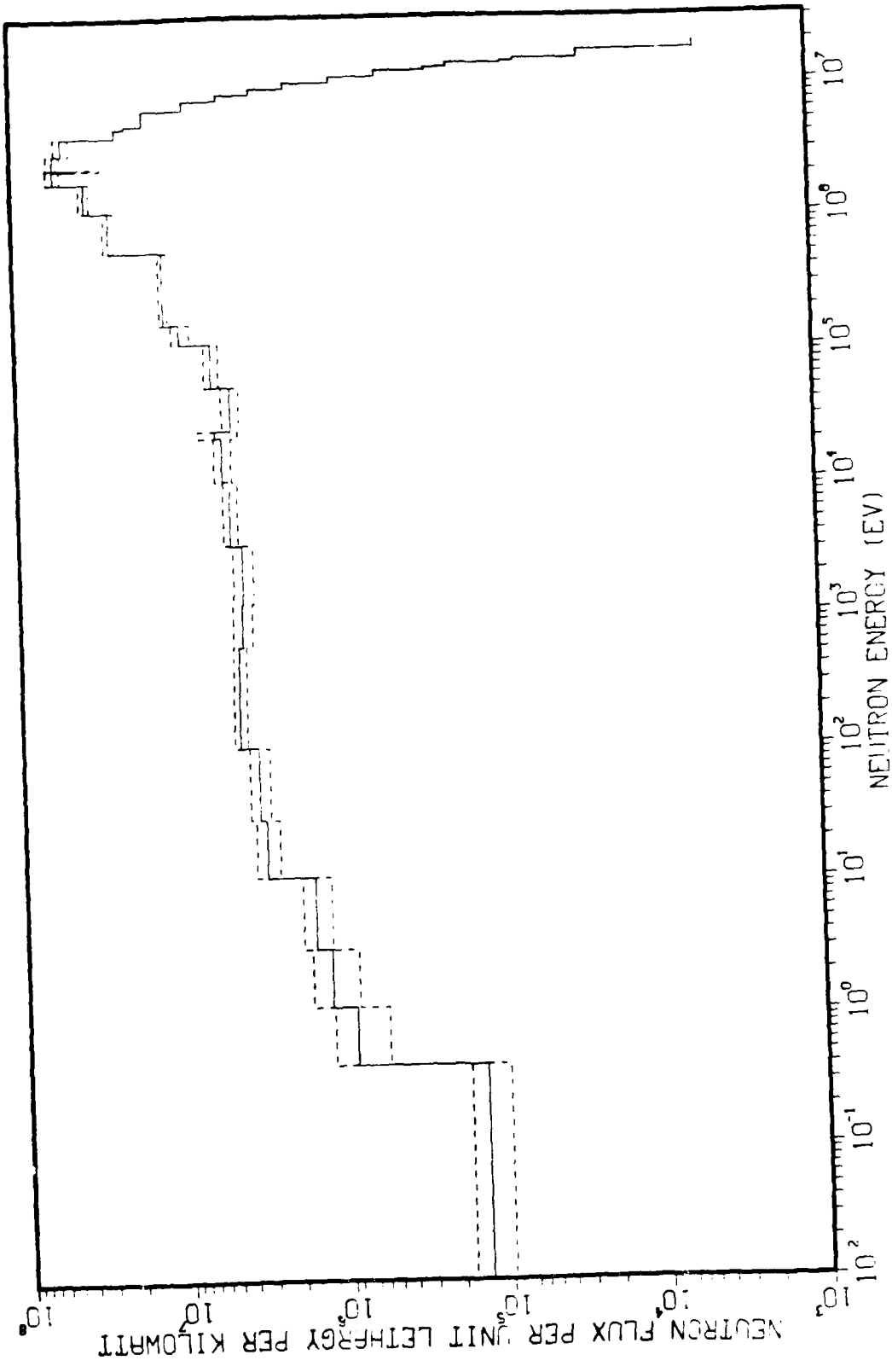

Figure II.4.4. Total (Front+Back) Neutron Flux vs Energy ERI Free Field.

Table II.4.12. Neutron Flux per Unit Lethargy per Kilowatt.

ERI FREE FIELD

GROUP	ENERGY (EV)	FRONT	BACK	TOTAL
1	1.960E+07	4.97E+03	0.00E+00	4.97E+03
2	1.690E+07	2.66E+04	0.00E+00	2.66E+04
3	1.490E+07	6.56E+04	0.00E+00	6.56E+04
4	1.420E+07	7.91E+04	0.00E+00	7.91E+04
5	1.380E+07	1.74E+05	0.00E+00	1.74E+05
6	1.280E+07	2.41E+05	0.00E+00	2.41E+05
7	1.220E+07	4.93E+05	0.00E+00	4.93E+05
8	1.110E+07	9.53E+05	0.00E+00	9.53E+05
9	1.000E+07	1.86E+06	0.00E+00	1.86E+06
10	9.050E+06	3.07E+06	0.00E+00	3.07E+06
11	8.190E+06	4.91E+06	0.00E+00	4.91E+06
12	7.410E+06	8.13E+06	7.06E-02	8.13E+06
13	6.380E+06	1.48E+07	3.20E+03	1.48E+07
14	4.970E+06	1.89E+07	9.47E+03	1.89E+07
15	4.720E+06	2.22E+07	3.22E+04	2.22E+07
16	4.070E+06	4.78E+07	6.52E+04	4.79E+07
		0.11	0.69	0.11
17	3.010E+06	5.37E+07	3.39E+05	5.41E+07
		0.10	0.29	0.10
18	2.390E+06	3.80E+07	4.43E+05	3.84E+07
		0.29	0.30	0.29
19	2.310E+06	5.36E+07	4.97E+05	5.41E+07
		0.10	0.34	0.10
20	1.830E+06	3.47E+07	2.68E+05	3.49E+07
		0.07	0.12	0.07
21	1.110E+06	2.45E+07	3.64E+05	2.47E+07
		0.07	0.11	0.07
22	5.500E+05	1.12E+07	2.89E+05	1.15E+07
		0.06	0.10	0.06
23	1.580E+05	8.97E+06	2.11E+05	9.18E+06
		0.13	0.15	0.13
24	1.110E+05	5.68E+06	2.18E+05	5.90E+06
		0.11	0.17	0.10
25	5.250E+04	4.40E+06	1.45E+05	4.53E+06
		0.13	0.15	0.12
26	2.480E-04	5.57E+06	1.06E+05	5.68E+06
		0.28	0.49	0.28
27	2.190E+04	5.01E+06	1.62E+05	5.17E+06
		0.13	0.17	0.13
28	1.030E+04	4.55E+06	1.58E+05	4.70E+06
		0.11	0.12	0.11
29	3.350E+03	3.82E+06	1.89E+05	4.01E+06
		0.15	0.25	0.15
30	1.230E+03	3.93E+06	1.77E+05	4.11E+06
		0.15	0.20	0.14
31	5.830E+02	4.16E+06	1.67E+05	4.33E+06
		0.10	0.10	0.09
32	1.010E+02	3.18E+06	1.80E+05	3.36E+06
		0.15	0.12	0.14
33	2.900E+01	2.87E+06	1.99E+05	3.06E+06
		0.18	0.16	0.17
34	1.070E+01	1.39E+06	1.72E+05	1.56E+06
		0.23	0.12	0.20
35	3.060E+00	1.11E+06	1.38E+05	1.25E+06
		0.36	0.13	0.32
36	1.130E+00	7.36E+05	1.57E+05	8.93E+05
		0.45	0.16	0.37
37	4.140E-01	3.78E+04	9.83E-04	1.36E+05
		0.48	0.33	0.28

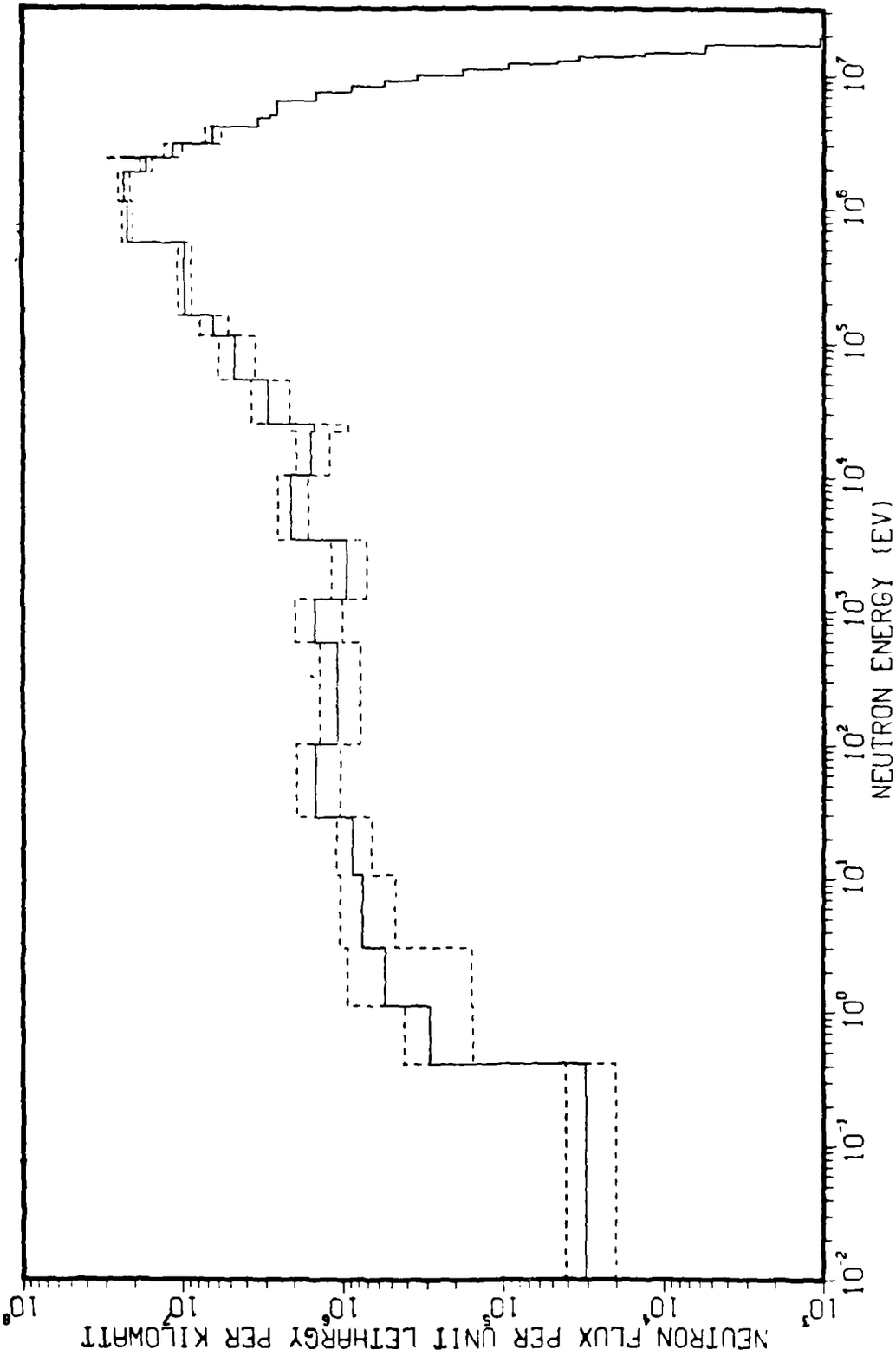

Figure II.4.5. Front Neutron Flux vs Energy ERI with 6" Pb.

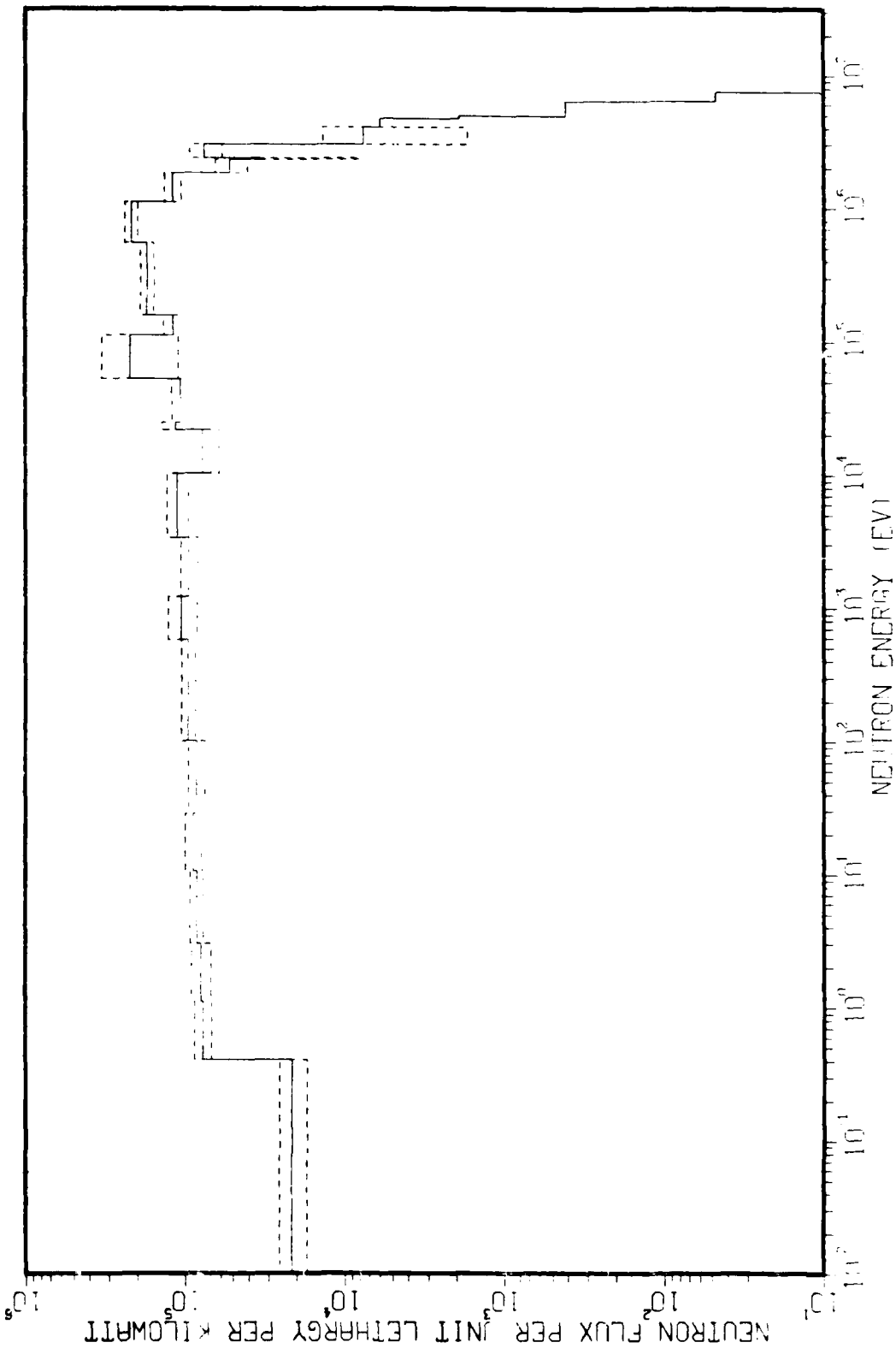

Figure II.4.6. Back Neutron Flux vs Energy ER1 with 6" Pb.

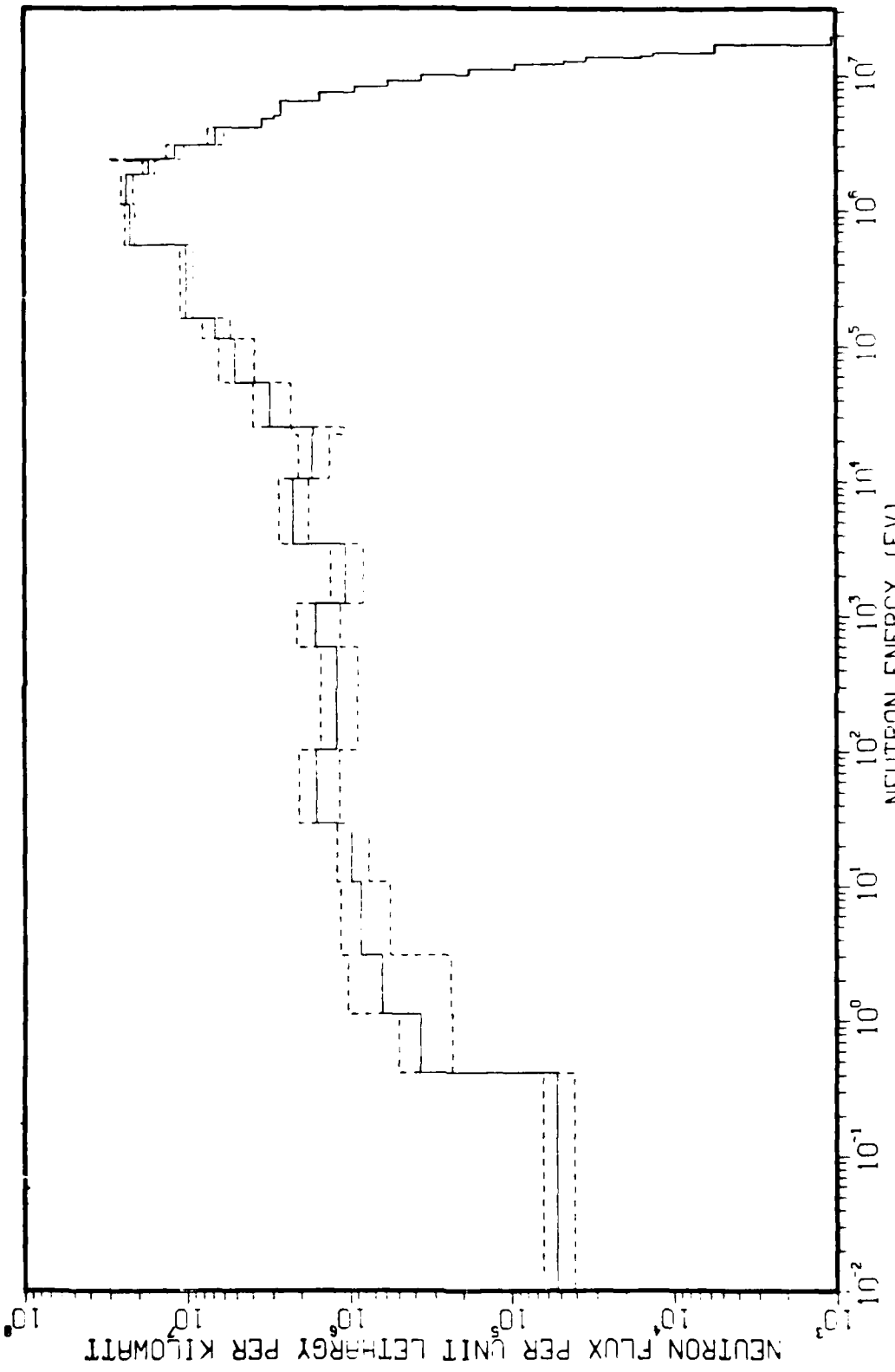

Figure II.4.7. Total (Front+Back) Neutron Flux vs Energy ER1 with 6" Pb.

Table II.4.13. Neutron Flux per Unit Lethargy per Kilowatt.

ERI WITH 6 IN. PB

GROUP	ENERGY (EV)	FRONT	BACK	TOTAL
1	1.960E+07	1.06E+03	0.00E+00	1.06E+03
2	1.690E+07	5.49E+03	0.00E+00	5.49E+03
3	1.490E+07	1.31E+04	0.00E+00	1.31E+04
4	1.420E+07	1.54E+04	0.00E+00	1.54E+04
5	1.380E+07	3.38E+04	0.00E+00	3.38E+04
6	1.280E+07	4.59E+04	0.00E+00	4.59E+04
7	1.220E+07	9.26E+04	0.00E+00	9.26E+04
8	1.110E+07	1.79E+05	0.00E+00	1.79E+05
9	1.000E+07	3.48E+05	0.00E+00	3.48E+05
10	9.050E+06	5.63E+05	0.00E+00	5.63E+05
11	8.190E+06	9.04E+05	0.00E+00	9.04E+05
12	7.410E+06	1.49E+06	4.75E+01	1.49E+06
13	6.380E+06	2.59E+06	4.20E+02	2.59E+06
14	4.970E+06	2.86E+06	1.91E+03	2.86E+06
15	4.720E+06	3.38E+06	5.99E+03	3.39E+06
16	4.070E+06	6.54E+06	7.63E+03	6.55E+06
		0.12	0.77	0.12
17	3.010E+06	1.16E+07	7.57E+04	1.17E+07
		0.13	0.22	0.13
18	2.390E+06	2.21E+07	3.21E+04	2.21E+07
		0.36	0.75	0.36
19	2.310E+06	1.70E+07	5.23E+04	1.70E+07
		0.09	0.23	0.09
20	1.830E+06	2.33E+07	1.20E+05	2.34E+07
		0.08	0.12	0.08
21	1.110E+06	2.22E+07	2.18E+05	2.24E+07
		0.08	0.09	0.08
22	5.500E+05	9.81E+06	1.72E+05	9.98E+06
		0.09	0.10	0.09
23	1.580E+05	6.53E+06	1.18E+05	6.65E+06
		0.20	0.15	0.19
24	1.110E+05	4.82E+06	2.21E+05	5.04E+06
		0.26	0.50	0.25
25	5.250E+04	2.96E+06	1.07E+05	3.07E+06
		0.27	0.13	0.26
26	2.480E+04	1.54E+06	1.15E+05	1.65E+06
		0.33	0.21	0.33
27	2.190E+04	1.61E+06	6.93E+04	1.68E+06
		0.23	0.12	0.22
28	1.030E+04	2.13E+06	1.12E+05	2.24E+06
		0.22	0.16	0.20
29	3.350E+03	9.68E+05	9.49E+04	1.06E+06
		0.25	0.12	0.23
30	1.230E+03	1.52E+06	1.06E+05	1.63E+06
		0.32	0.20	0.30
31	5.830E+02	1.10E+06	9.59E+04	1.20E+06
		0.28	0.10	0.26
32	1.010E+02	1.51E+06	8.51E+04	1.60E+06
		0.30	0.12	0.28
33	2.900E+01	8.92E+05	6.96E+04	9.82E+05
		0.25	0.12	0.22
34	1.070E+01	7.71E+05	8.49E+04	8.56E+05
		0.38	0.09	0.34
35	3.060E+00	5.55E+05	7.99E+04	6.35E+05
		0.71	0.14	0.62
36	1.130E+00	2.89E+05	7.76E+04	3.67E+05
		0.46	0.12	0.36
37	4.140E-01	3.09E+04	2.15E+04	5.25E+04
		0.35	0.19	0.22

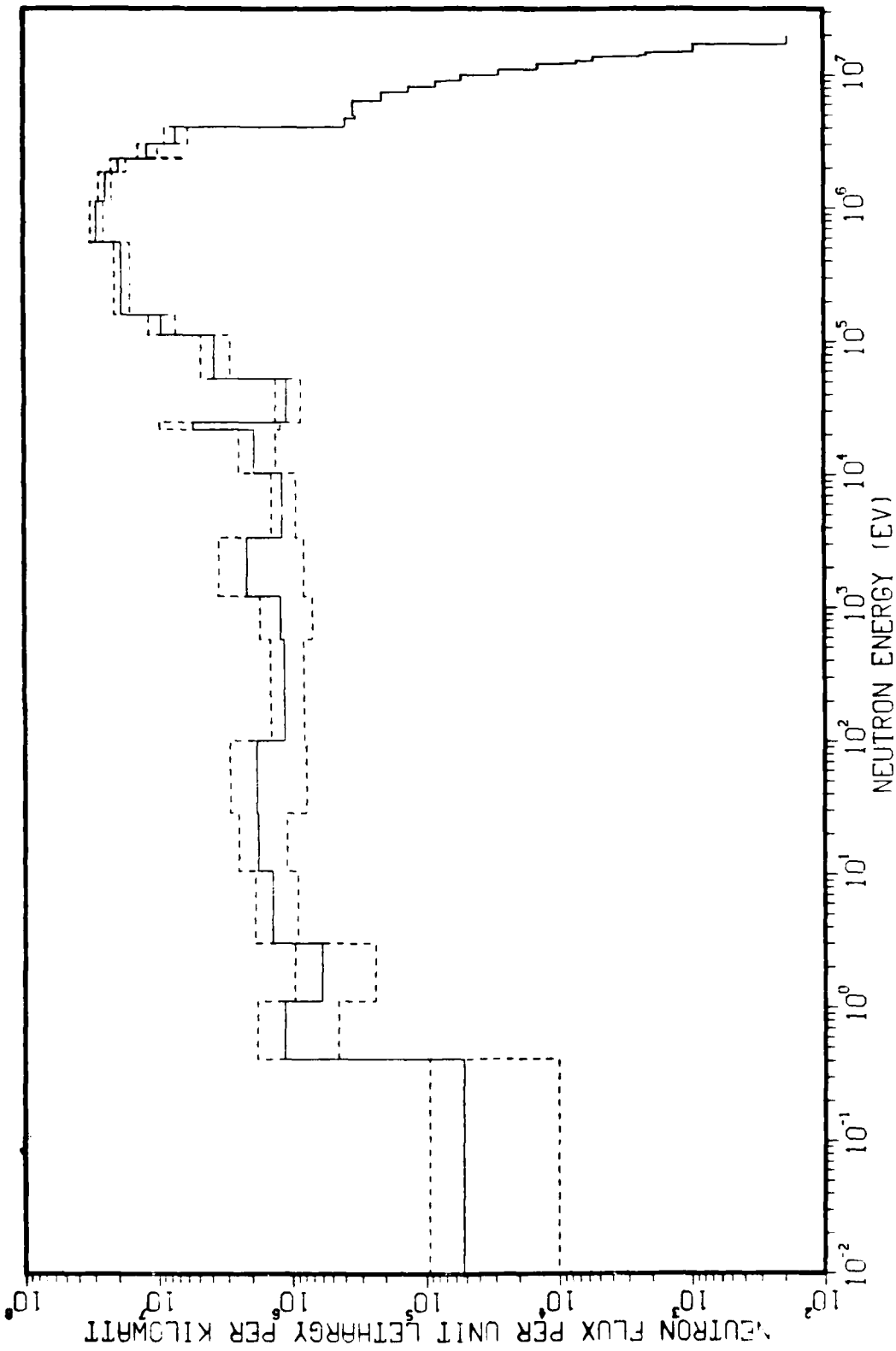

Figure II.4.8. Front Neutron Flux vs Energy ER1 with 6" Pb and 2" Cave.

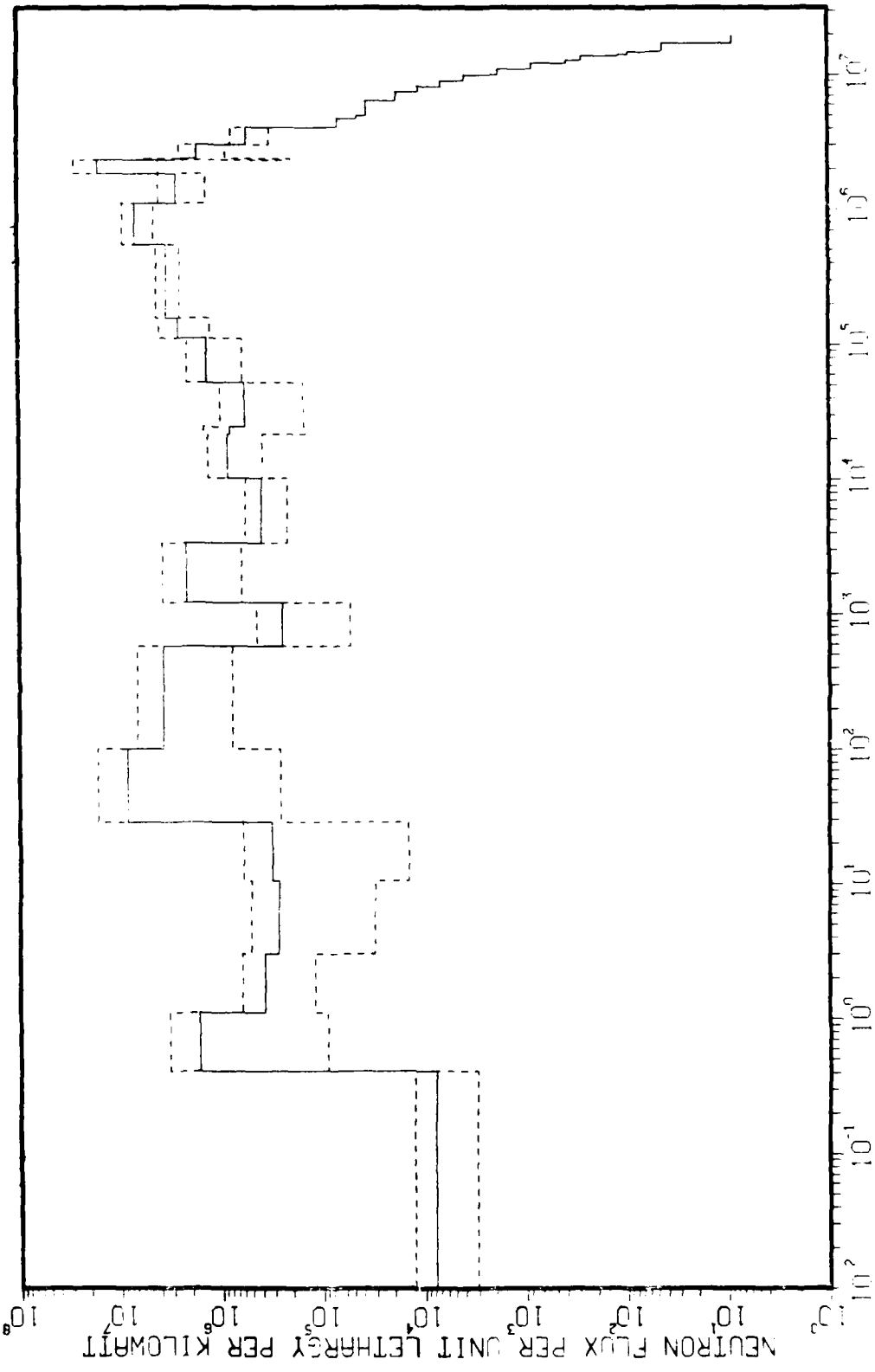

Figure II.4.9. Back Neutron Flux vs Energy ER1 with 6" Pb and 2" Cave.

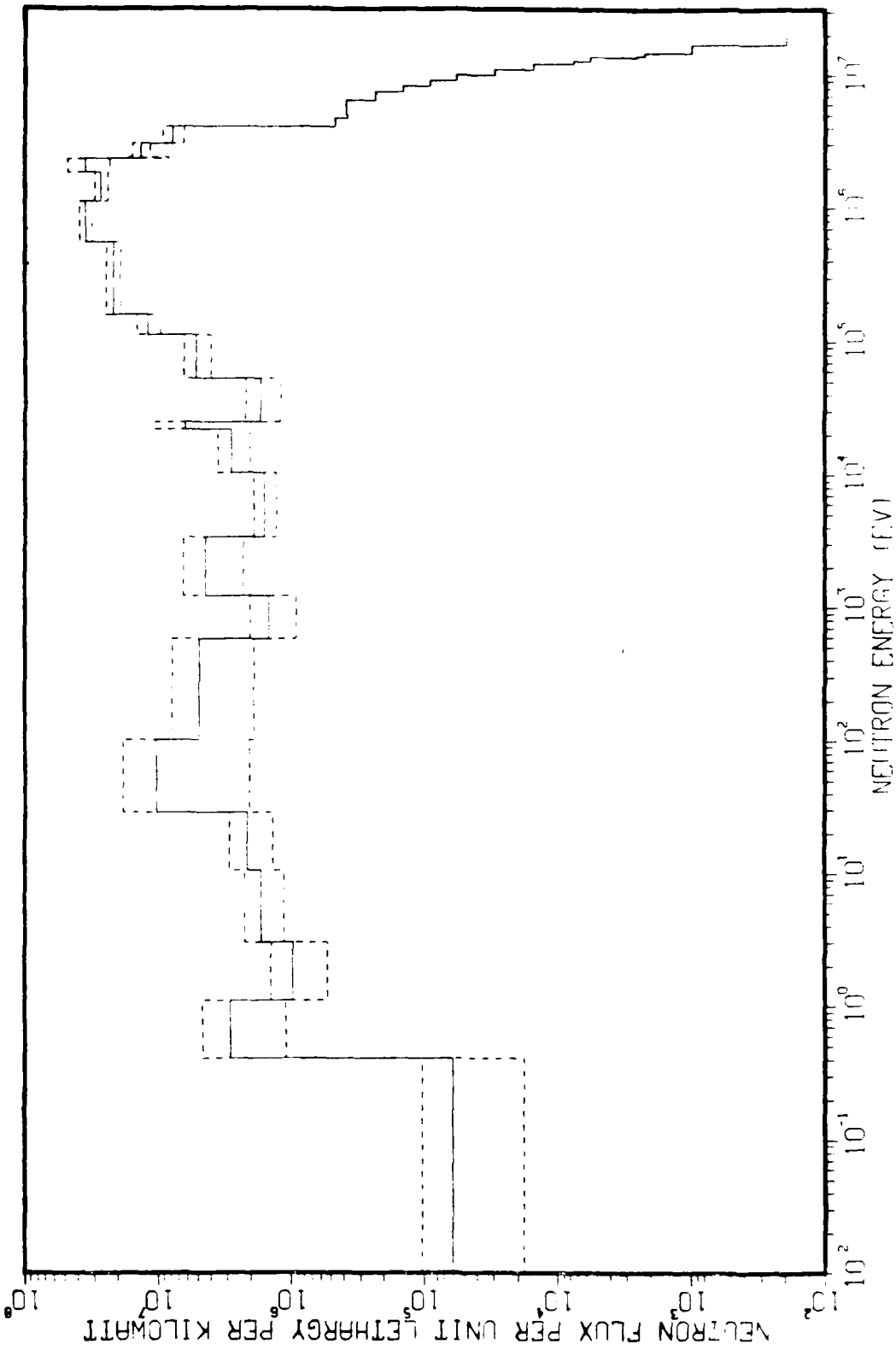

Figure II.4.10. Total (Front+Back) Neutron Flux vs Energy ER1 with 6" Pb and 2" Cave.

Table II.4.14. Neutron Flux per Unit Lethargy per Kilowatt.

ERI WITH 6 IN. PB AND 2 IN. CAVE

GROUP	ENERGY (EV)	FRONT	BACK	TOTAL
1	1.960E+07	1.88E+02	8.82E-00	1.96E+02
2	1.690E+07	9.46E+02	4.3[illegible]E+01	9.89E+02
3	1.490E+07	2.13E+03	9.50E+01	2.23E+03
4	1.420E+07	2.43E+03	1.19E+02	2.55E+03
5	1.380E+07	5.38E+03	2.74E-02	5.65E+03
6	1.280E+07	7.13E+03	3.87E-02	7.52E+03
7	1.220E+07	1.42E+04	8.5[illegible]E-02	1.51E+04
8	1.110E+07	2.74E+04	1.82E+03	2.92E+04
9	1.000E+07	5.27E+04	3.91E+03	5.66E+04
10	9.050E+06	8.23E+04	6.64E+03	8.89E+04
11	8.190E+06	1.32E+05	1.11E+04	1.43E+05
12	7.410E+06	2.16E+05	1.83E+04	2.31E+05
13	6.380E+06	3.45E+05	3.60E+04	3.81E+05
14	4.970E+06	3.31E+05	4.42E+04	3.75E+05
15	4.720E+06	3.98E+05	6.96E-04	4.68E+05
16	4.070E+06	7.28E+06 0.20	5.48E+05 0.41	7.83E-06 0.19
17	3.010E+06	1.18E+07 0.16	1.66E-06 0.48	1.35E+07 0.16
18	2.390E+06	1.02E+07 0.39	2.86E-06 0.93	1.3[illegible]E-07 0.36
19	2.310E+06	1.95E+07 0.13	1.58E-07 0.75	3.53E+07 0.34
20	1.830E+06	2.44E+07 0.11	2.68E+06 0.49	2.71E+07 0.11
21	1.110E+06	2.84E+07 0.11	6.82E+06 0.34	3.52E+07 0.11
22	5.500E+05	1.85E+07 0.14	3.40E+06 0.26	2.19E+07 0.13
23	1.580E+05	9.45E+06 0.22	2.61E+06 0.52	1.21E+07 0.21
24	1.110E+05	3.83E+06 0.24	1.38E+06 0.56	5.21E+06 0.23
25	5.250E+04	1.10E+06 0.21	5.82E+05 0.74	1.68E+06 0.29
26	2.480E+04	5.44E+06 0.77	8.18E+05 0.82	6.26E+06 0.68
27	2.190E+04	1.92E+06 0.30	8.65E+05 0.55	2.78E+06 0.27
28	1.030E+04	1.19E+06 0.21	3.98E+05 0.45	1.59E+06 0.19
29	3.350E+03	2.18E+06 0.62	2.22E+06 0.72	4.40E+06 0.48
30	1.230E+03	1.23E+06 0.42	2.50E+05 0.78	1.48E+06 0.37
31	5.830E+02	1.14E+06 0.28	3.77E+06 0.79	4.91E+06 0.6[illegible]
32	1.010E+02	1.87E+06 0.58	8.48E+06 0.97	1.03E+07 0.6[illegible]
33	2.900E+01	1.81E+06 0.39	3.19E+05 0.95	2.13E+06 0.36
34	1.070E+01	1.41E+06 0.35	2.75E+05 0.89	1.69E+06 0.33
35	3.060E+00	6.01E+05 0.60	3.77E+05 0.68	9.78E+05 0.45
36	1.130E+00	1.15E+06 0.60	1.71E+06 0.95	2.86E+06 0.62
37	4.140E-01	5.25E+04 0.81	7.90E+03 0.61	6.04E+04 0.71

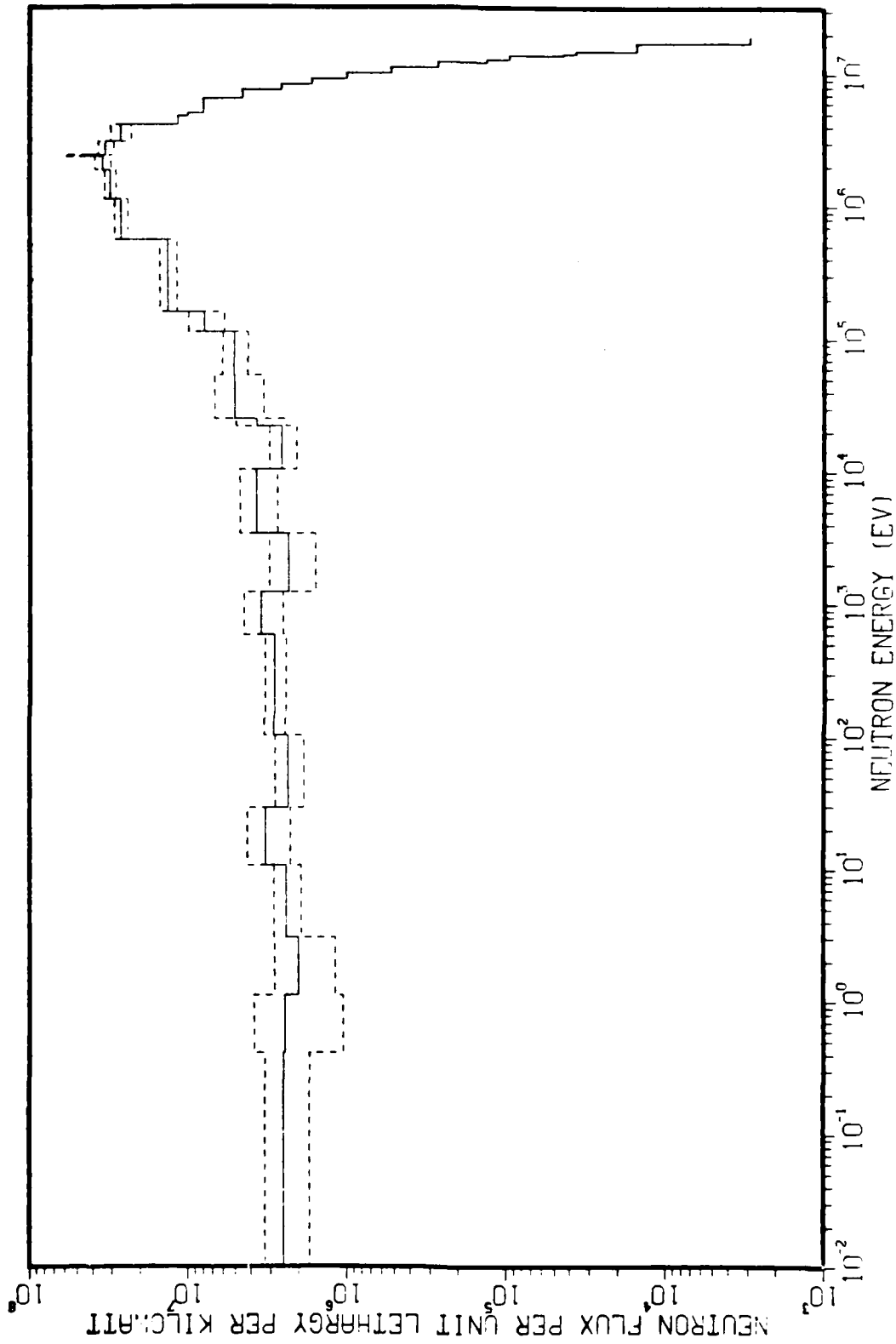

Figure II.4.11. Front Neutron Flux vs Energy ER1 with Exercise Wheel.

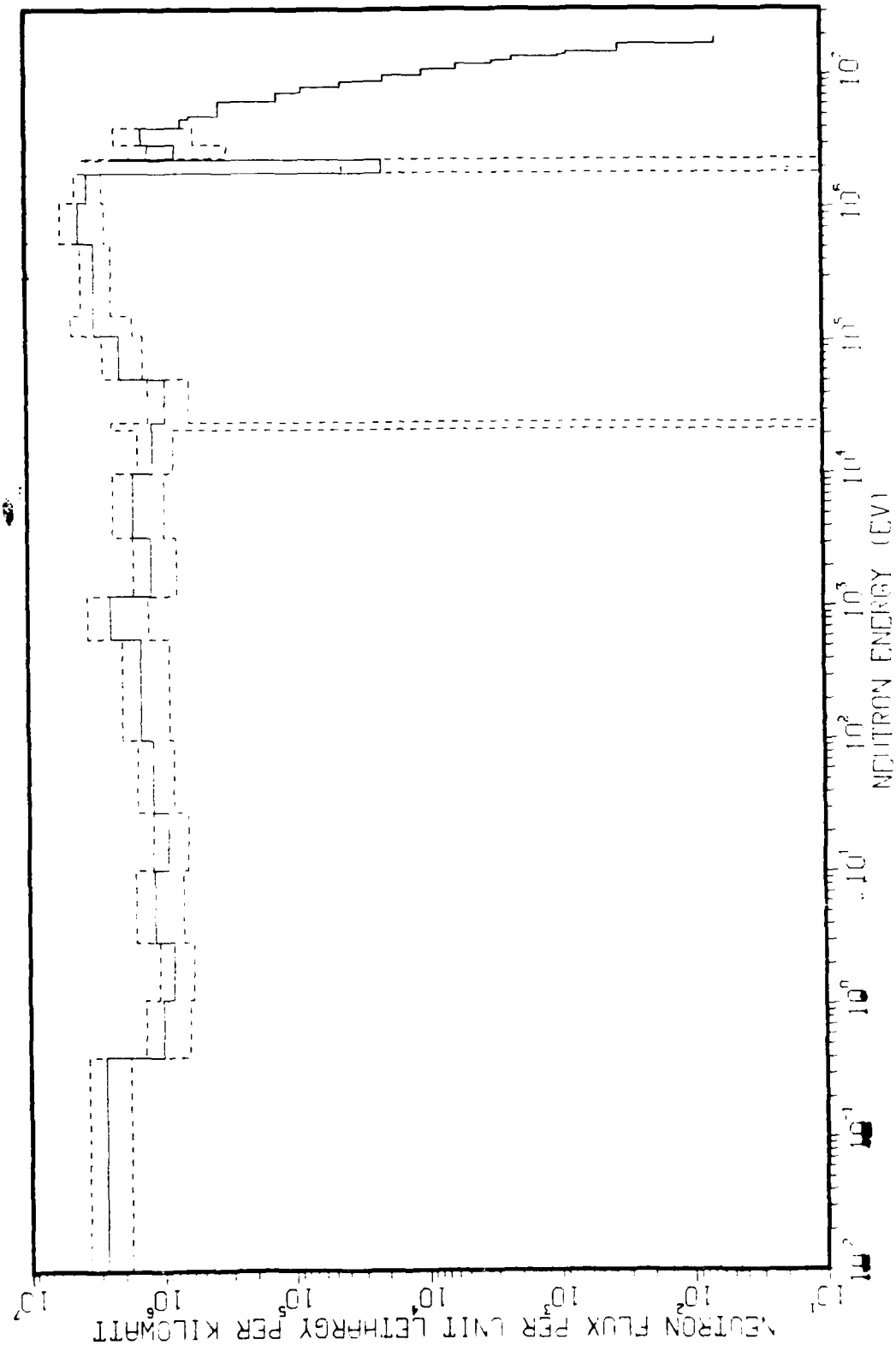

Figure II.4.12. Back Neutron Flux vs Energy ER1 with Exercise Wheel.

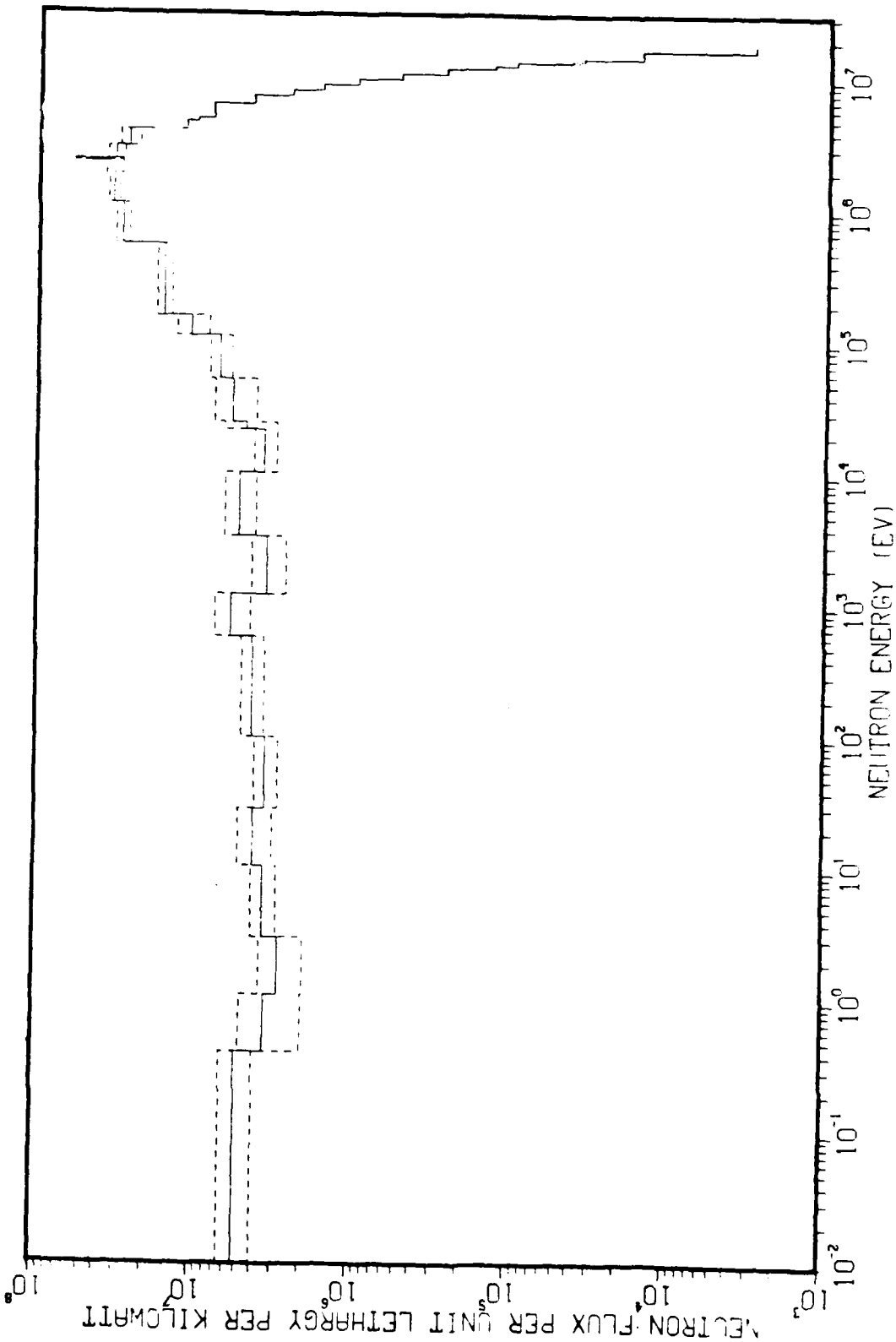

Figure II.4.13. Total (Front+Back) Neutron Flux vs Energy ER1 with Exercise Wheel.

Table II.4.15. Neutron Flux per Unit Lethargy per Kilowatt.

		ERI WITH EXERCISE WHEEL		
GROUP	ENERGY (EV)	FRONT	BACK	TOTAL
1	1.900E+07	2.90E+03	6.16E+01	2.96E+03
2	1.690E+07	1.51E+04	3.29E+02	1.54E+04
3	1.490E+07	3.63E+04	8.02E+02	3.71E+04
4	1.420E+07	4.33E+04	9.11E+02	4.42E+04
5	1.380E+07	9.49E+04	2.04E+03	9.69E+04
6	1.280E+07	1.32E+05	2.89E+03	1.35E+05
7	1.220E+07	2.65E+05	5.45E+03	2.70E+05
8	1.110E+07	5.15E+05	9.97E+03	5.25E+05
9	1.000E+07	9.78E+05	1.99E+04	9.98E+05
10	9.050E+06	1.63E+06	4.17E+04	1.67E+06
11	8.190E+06	2.51E+06	8.16E+04	2.59E+06
12	7.410E+06	4.42E+06	1.28E+05	4.55E+06
13	6.380E+06	7.85E+06	3.46E+05	8.20E+06
14	4.970E+06	9.77E+06	5.79E+05	1.04E+07
15	4.720E+06	1.14E+07	6.77E+05	1.21E+07
16	4.070E+06	2.62E+07	1.35E+06	2.75E+07
		0.15	0.60	0.14
17	3.010E+06	3.27E+07	7.54E+05	3.34E+07
		0.12	0.60	0.11
18	2.390E+06	4.53E+07	2.24E+06	4.75E+07
		0.31	0.66	0.30
19	2.310E+06	3.41E+07	2.03E+04	3.41E+07
		0.12	1.00	0.12
20	1.830E+06	3.05E+07	3.44E+06	3.39E+07
		0.08	0.23	0.08
21	1.110E+06	2.62E+07	3.99E+06	3.01E+07
		0.10	0.36	0.10
22	5.500E+05	1.32E+07	3.07E+06	1.62E+07
		0.12	0.26	0.11
23	1.580E+05	7.82E+06	3.03E+06	1.09E+07
		0.25	0.48	0.23
24	1.110E+05	5.08E+06	2.02E+06	7.10E+06
		0.18	0.33	0.16
25	5.250E+04	5.01E+06	9.17E+05	5.93E+06
		0.34	0.35	0.30
26	2.480E+04	3.66E+06	1.16E+06	4.82E+06
		0.35	1.00	0.36
27	2.190E+04	2.53E+06	1.14E+06	3.67E+06
		0.19	0.30	0.16
28	1.030E+04	3.70E+06	1.61E+06	5.31E+06
		0.27	0.42	0.23
29	3.350E+03	2.31E+06	1.19E+06	3.50E+06
		0.32	0.36	0.24
30	1.230E+03	3.48E+06	2.41E+06	5.89E+06
		0.27	0.48	0.25
31	5.830E+02	2.84E+06	1.43E+06	4.26E+06
		0.15	0.38	0.16
32	1.010E+02	2.31E+06	1.18E+06	3.49E+06
		0.20	0.31	0.17
33	2.900E+01	3.23E+06	9.07E+05	4.13E+06
		0.30	0.30	0.24
34	1.070E+01	2.39E+06	1.15E+06	3.54E+06
		0.19	0.34	0.18
35	3.060E+00	2.00E+06	8.29E+05	2.83E+06
		0.41	0.29	0.30
36	1.130E+00	2.43E+06	9.99E+05	3.43E+06
		0.57	0.37	0.42
37	4.140E-01	2.49E+06	2.71E+06	5.20E+06
		0.31	0.34	0.23

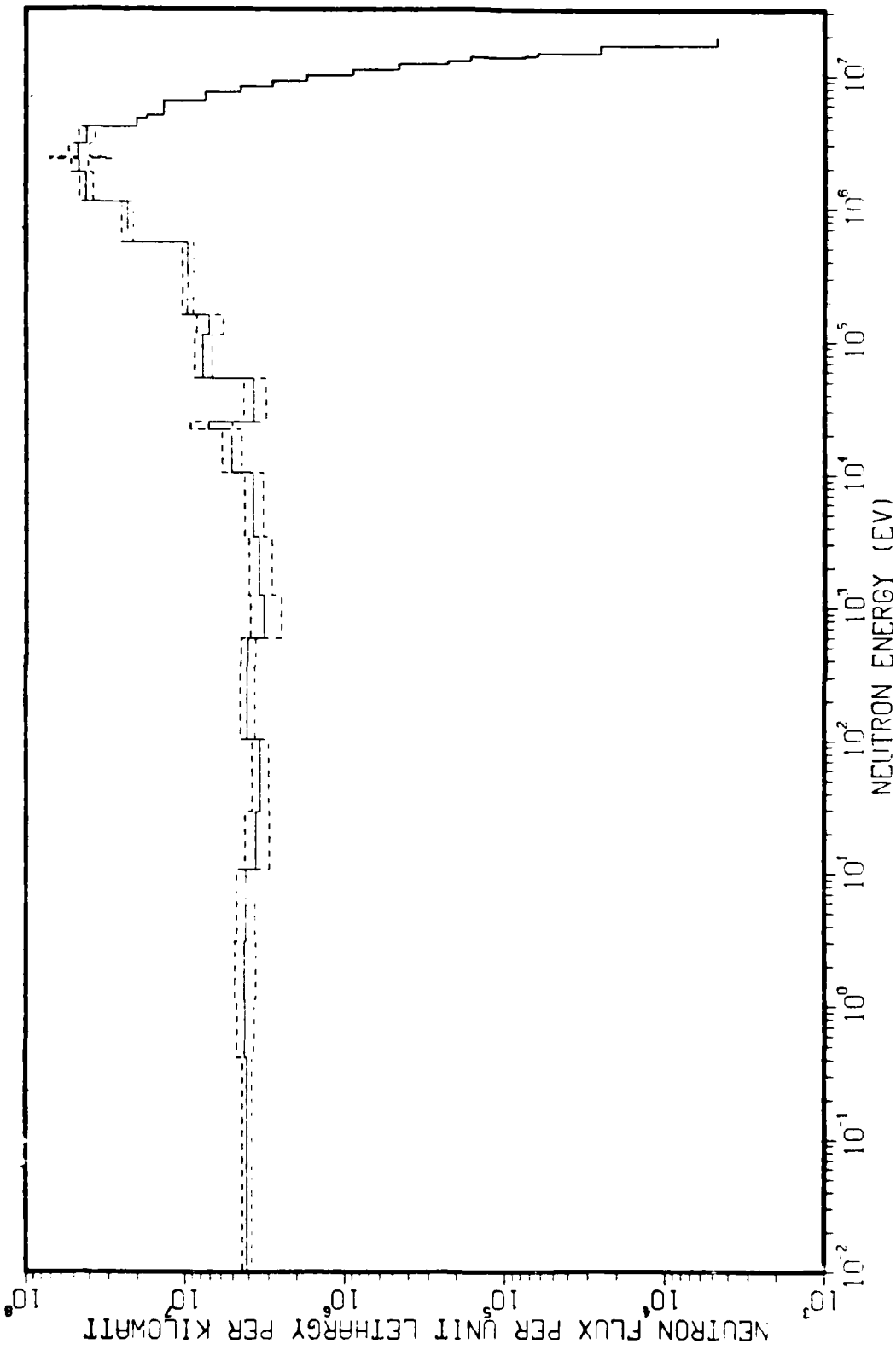

Figure II.4.14. Front Neutron Flux vs Energy ER2 Free Field.

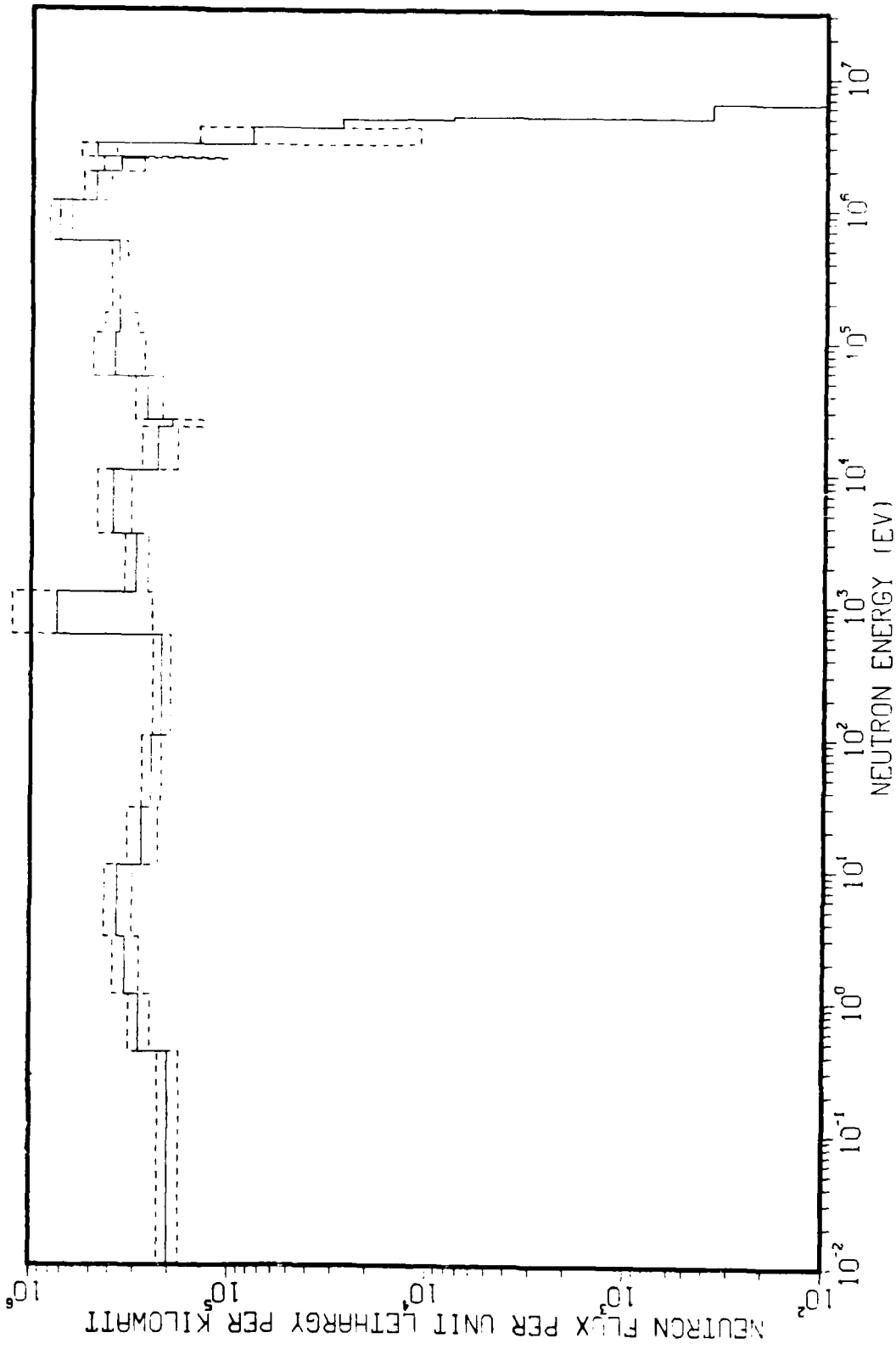

Figure II.4.15. Back Neutron Flux vs Energy ER2 Free Field.

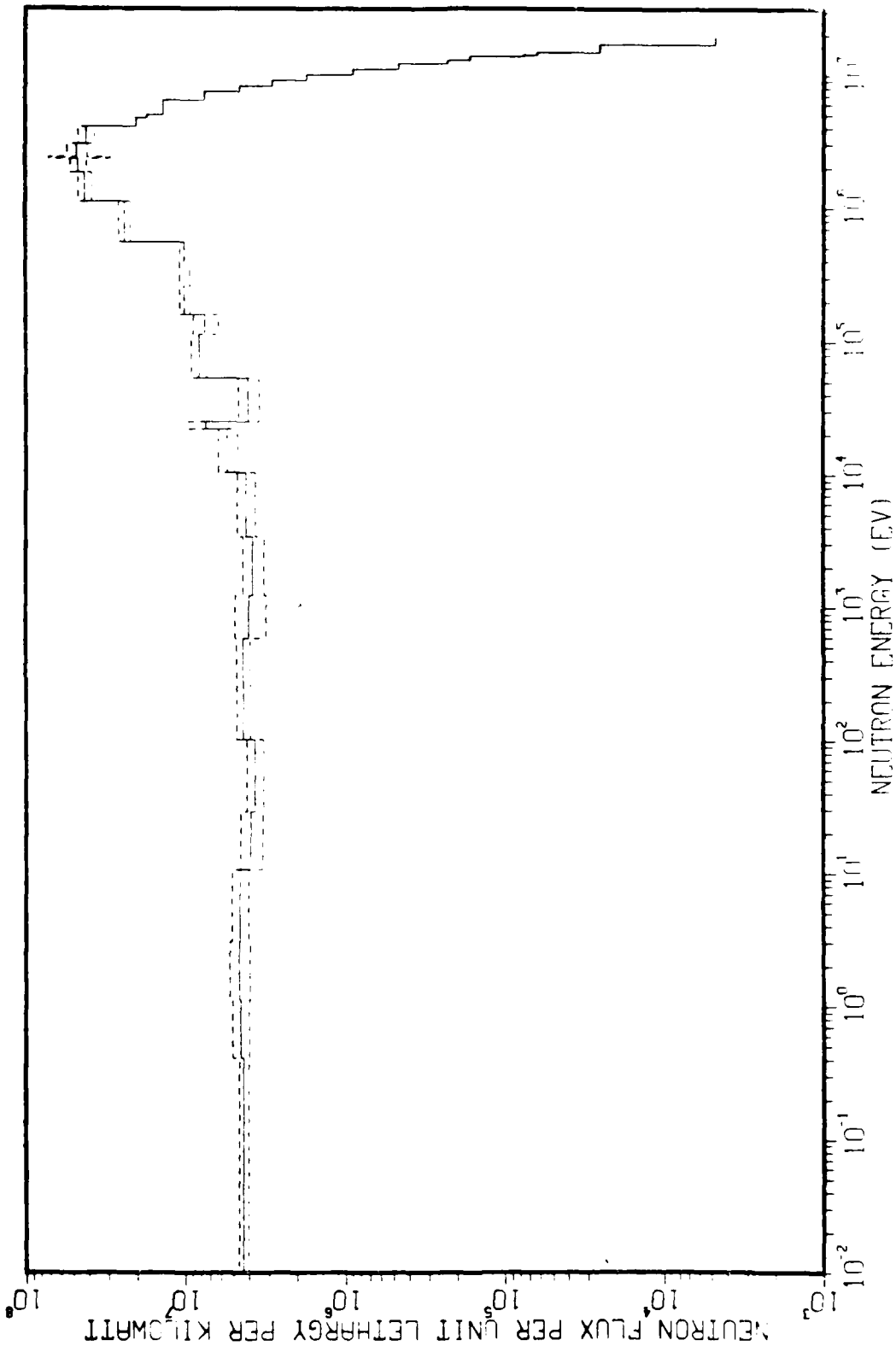

Figure II.4.16. Total (Front+Back) Neutron Flux vs Energy ER2 Free Field.

Table II.4.16. Neutron Flux per Unit Lethargy per Kilowatt.

ER2 FREE FIELD

GROUP	ENERGY (EV)	FRONT	BACK	TOTAL
1	1.960E+07	4.71E+03	0.00E+00	4.71E+03
2	1.690E+07	2.51E+04	0.00E+00	2.51E+04
3	1.490E+07	6.19E+04	0.00E+00	6.19E+04
4	1.420E+07	7.45E+04	0.00E+00	7.45E+04
5	1.380E+07	1.63E+05	0.00E+00	1.63E+05
6	1.280E+07	2.26E+05	0.00E+00	2.26E+05
7	1.220E+07	4.62E+05	0.00E+00	4.62E+05
8	1.110E+07	8.93E+05	0.00E+00	8.93E+05
9	1.000E+07	1.73E+06	0.00E+00	1.73E+06
10	9.050E+06	2.85E+06	0.00E+00	2.85E+06
11	8.190E+06	4.56E+06	0.00E+00	4.56E+06
12	7.410E+06	7.53E+06	0.00E+00	7.53E+06
13	6.380E+06	1.36E+07	3.71E+02	1.36E+07
14	4.970E+06	1.73E+07	7.51E+03	1.74E+07
15	4.720E+06	2.02E+07	2.74E+04	2.02E+07
16	4.070E+06	4.16E+07	7.79E+04	4.17E+07
		0.12	0.86	0.12
17	3.010E+06	4.69E+07	4.76E+03	4.73E+07
		0.15	0.20	0.15
18	2.390E+06	4.99E+07	2.72E+03	5.02E+07
		0.42	0.61	0.42
19	2.310E+06	4.64E+07	3.58E+03	4.67E+07
		0.12	0.23	0.12
20	1.830E+06	4.19E+07	4.80E+03	4.24E+07
		0.10	0.16	0.09
21	1.110E+06	2.32E+07	7.29E+03	2.39E+07
		0.08	0.12	0.08
22	5.500E+05	9.71E+06	3.65E+03	1.01E+07
		0.07	0.09	0.07
23	1.580E+05	7.15E+06	3.65E+03	7.52E+06
		0.19	0.19	0.18
24	1.110E+05	7.81E+06	3.82E+03	8.19E+06
		0.12	0.29	0.12
25	5.250E+04	3.77E+06	2.61E+03	4.03E+06
		0.16	0.16	0.15
26	2.480E+04	7.23E+06	1.97E+03	7.43E+06
		0.29	0.31	0.28
27	2.190E+04	5.20E+06	2.31E+03	5.44E+06
		0.14	0.20	0.14
28	1.030E+04	3.80E+06	3.90E+03	4.19E+06
		0.14	0.19	0.13
29	3.350E+03	3.49E+06	2.98E+03	3.79E+06
		0.16	0.14	0.15
30	1.230E+03	3.27E+06	7.42E+03	4.01E+06
		0.22	0.67	0.22
31	5.830E+02	4.13E+06	2.21E+03	4.35E+06
		0.10	0.10	0.10
32	1.010E+02	3.44E+06	2.47E+03	3.69E+06
		0.12	0.11	0.11
33	2.900E+01	3.64E+06	2.76E+03	3.92E+06
		0.17	0.17	0.16
34	1.070E+01	4.22E+06	3.64E+03	4.59E+06
		0.13	0.16	0.12
35	3.060E+00	4.29E+06	3.34E+03	4.62E+06
		0.15	0.15	0.14
36	1.130E+00	4.26E+06	2.83E+03	4.54E+06
		0.12	0.12	0.11
37	4.140E-01	4.14E+06	2.01E+03	4.34E+06
		0.07	0.13	0.07

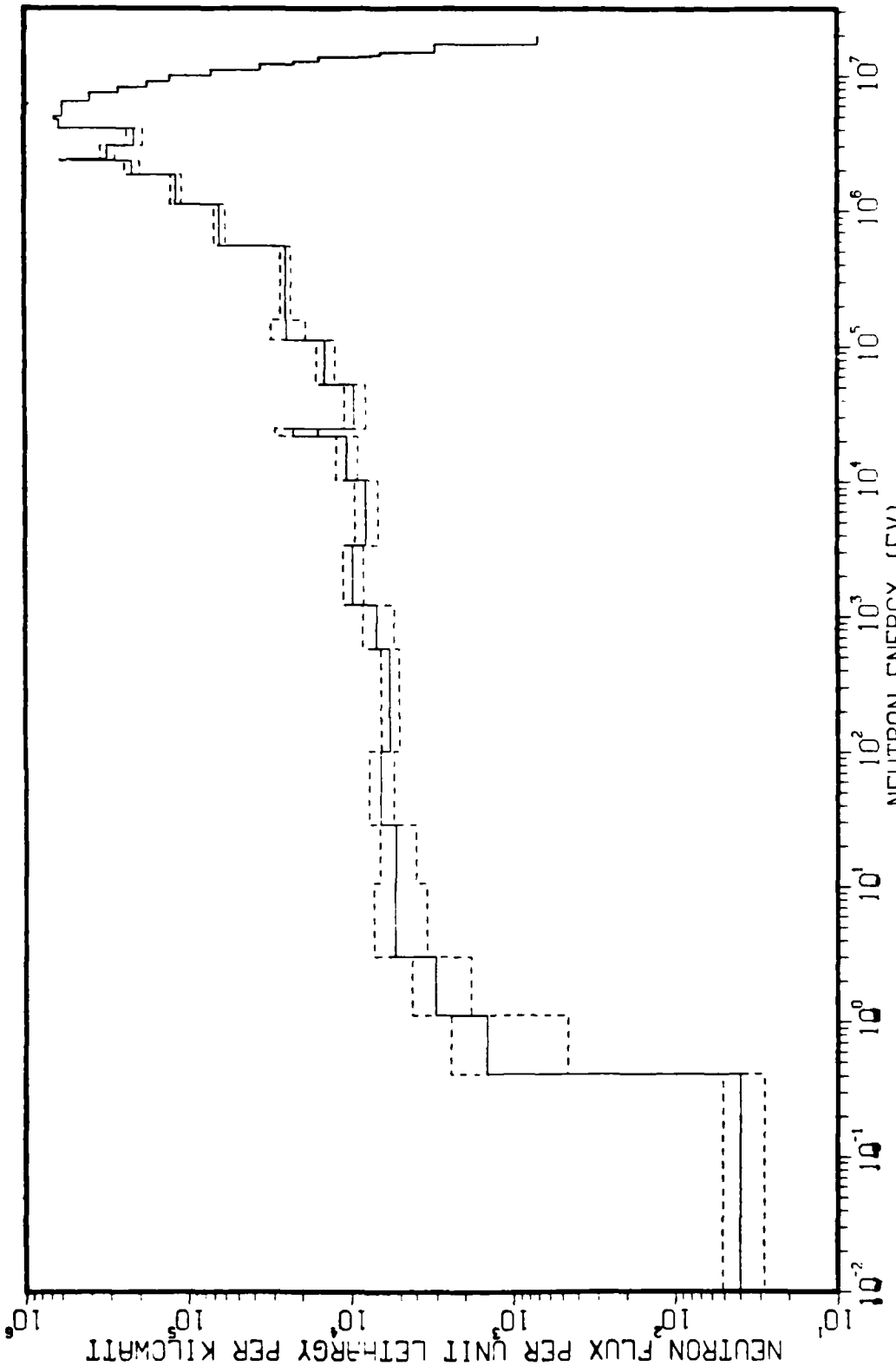

Figure II.4.17. Front Neutron Flux vs Energy ERI Free Field with 12" Water.

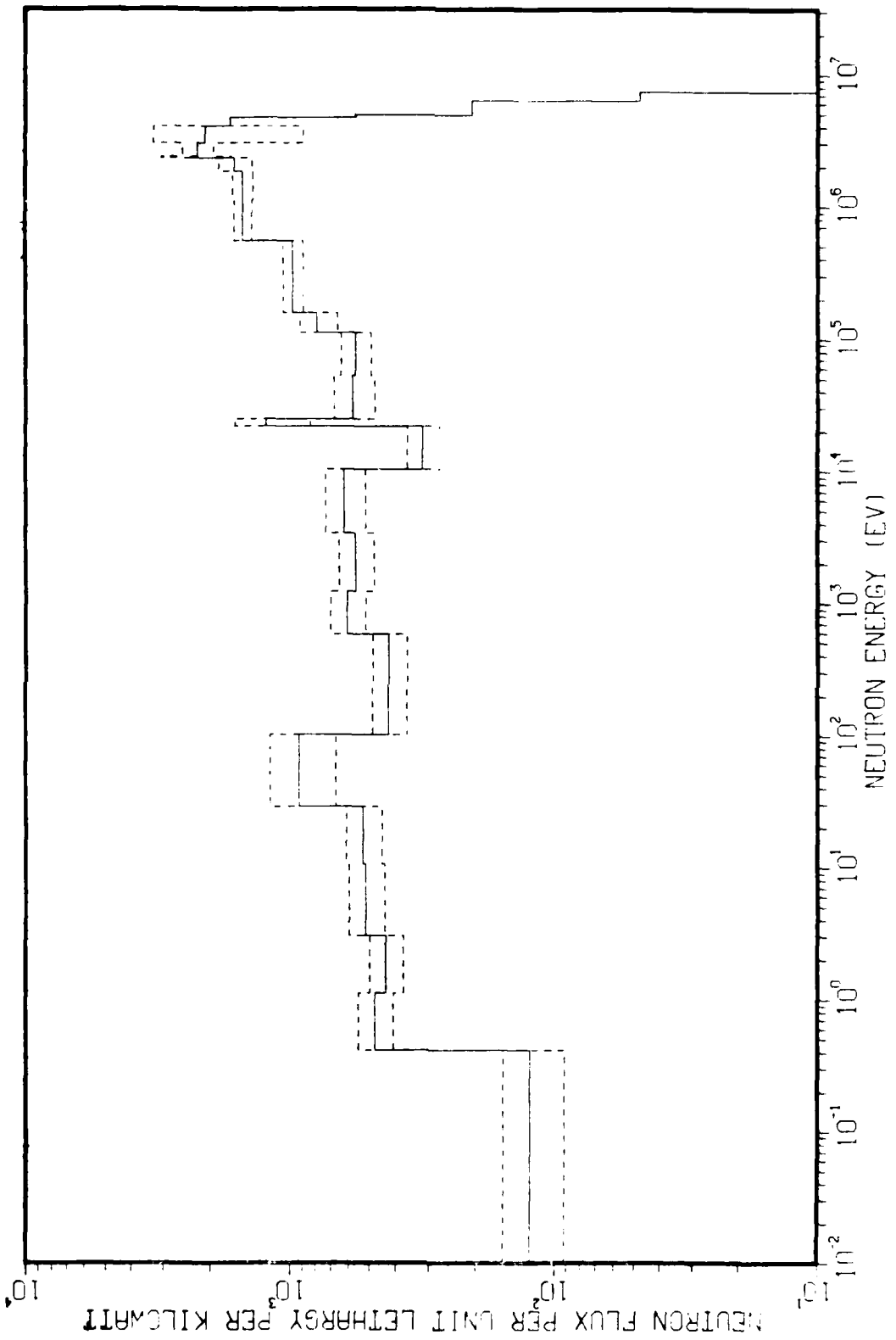

Figure II.4.18. Back Neutron Flux vs Energy ER1 Free Field with 12" Water.

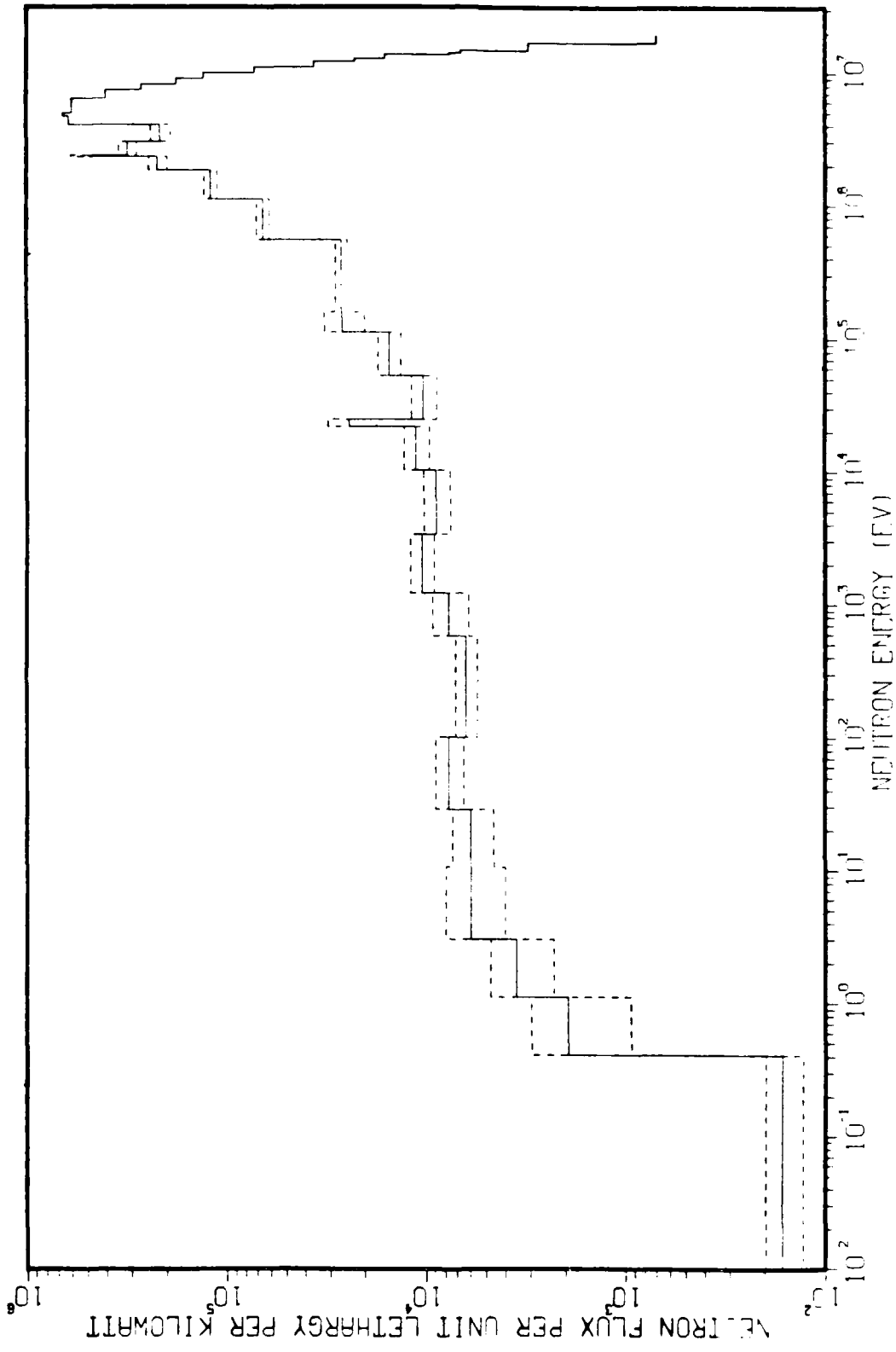

Figure II.4.19. Total (Front+Back) Neutron Flux vs Energy ERI Free Field with 12" Water.

Table II.4.17- Neutron Flux per Unit Lethargy per Kilowatt.

ERI FREE FIELD WITH 12 IN. WATER

GROUP	ENERGY (EV)	FRONT	BACK	TOTAL
1	1.960E+07	6.97E+02	0.00E+00	6.97E+02
2	1.690E+07	3.03E+03	0.00E+00	3.03E+03
3	1.490E+07	6.56E+03	0.00E+00	6.56E+03
4	1.420E+07	7.46E+03	0.00E+00	7.46E+03
5	1.380E+07	1.57E+04	0.00E+00	1.57E+04
6	1.280E+07	2.22E+04	0.00E+00	2.22E+04
7	1.220E+07	3.59E+04	0.00E+00	3.59E+04
8	1.110E+07	7.12E+04	0.00E+00	7.12E+04
9	1.000E+07	1.29E+05	0.00E+00	1.29E+05
10	9.050E+06	1.77E+05	0.00E+00	1.77E+05
11	8.190E+06	2.65E+05	0.00E+00	2.65E+05
12	7.410E+06	3.99E+05	4.74E-01	3.99E+05
13	6.380E+06	5.91E+05	2.04E+02	5.91E+05
14	4.970E+06	6.55E+05	5.62E+02	6.55E+05
15	4.720E+06	6.11E+05	1.67E+03	6.13E+05
16	4.070E+06	2.11E+05 0.11	2.07E+03 0.57	2.14E+05 0.11
17	3.010E+06	3.09E+05 0.10	2.23E+03 0.14	3.12E+05 0.10
18	2.390E+06	4.80E+05 0.25	2.34E+03 0.30	4.82E+05 0.24
19	2.310E+06	2.19E+05 0.11	1.62E+03 0.14	2.20E+05 0.11
20	1.830E+06	1.18E+05 0.07	1.50E+03 0.09	1.19E+05 0.07
21	1.110E+06	6.33E+04 0.03	1.49E+03 0.08	6.46E+04 0.08
22	5.500E+05	2.52E+04 0.07	9.69E+02 0.08	2.61E+04 0.07
23	1.580E+05	2.50E+04 0.24	7.86E+02 0.16	2.58E+04 0.23
24	1.110E+05	1.45E+04 0.13	5.65E+02 0.13	1.51E+04 0.12
25	5.250E+04	9.62E+03 0.15	5.79E+02 0.18	1.02E+04 0.14
26	2.480E+04	2.27E+04 0.29	1.23E+03 0.32	2.39E+04 0.28
27	2.190E+04	1.08E+04 0.15	3.16E+02 0.14	1.11E+04 0.14
28	1.030E+04	8.19E+03 0.16	6.23E+02 0.17	8.81E+03 0.15
29	3.350E+03	9.84E+03 0.14	5.64E+02 0.15	1.04E+04 0.13
30	1.230E+03	7.02E+03 0.22	6.07E+02 0.15	7.63E+03 0.20
31	5.830E+02	5.85E+03 0.13	4.24E+02 0.15	6.27E+03 0.12
32	1.010E+02	6.71E+03 0.16	9.27E+02 0.23	7.63E+03 0.16
33	2.900E+01	5.39E+03 0.25	5.29E+02 0.15	5.92E+03 0.23
34	1.070E+01	5.42E+03 0.36	5.17E+02 0.16	5.93E+03 0.33
35	3.060E+00	3.06E+03 0.40	4.35E+02 0.14	3.50E+03 0.35
36	1.130E+00	1.46E+03 0.68	4.78E+02 0.15	1.94E+03 0.52
37	4.140E-01	3.99E+01 0.29	1.24E+02 0.26	1.64E+02 0.21

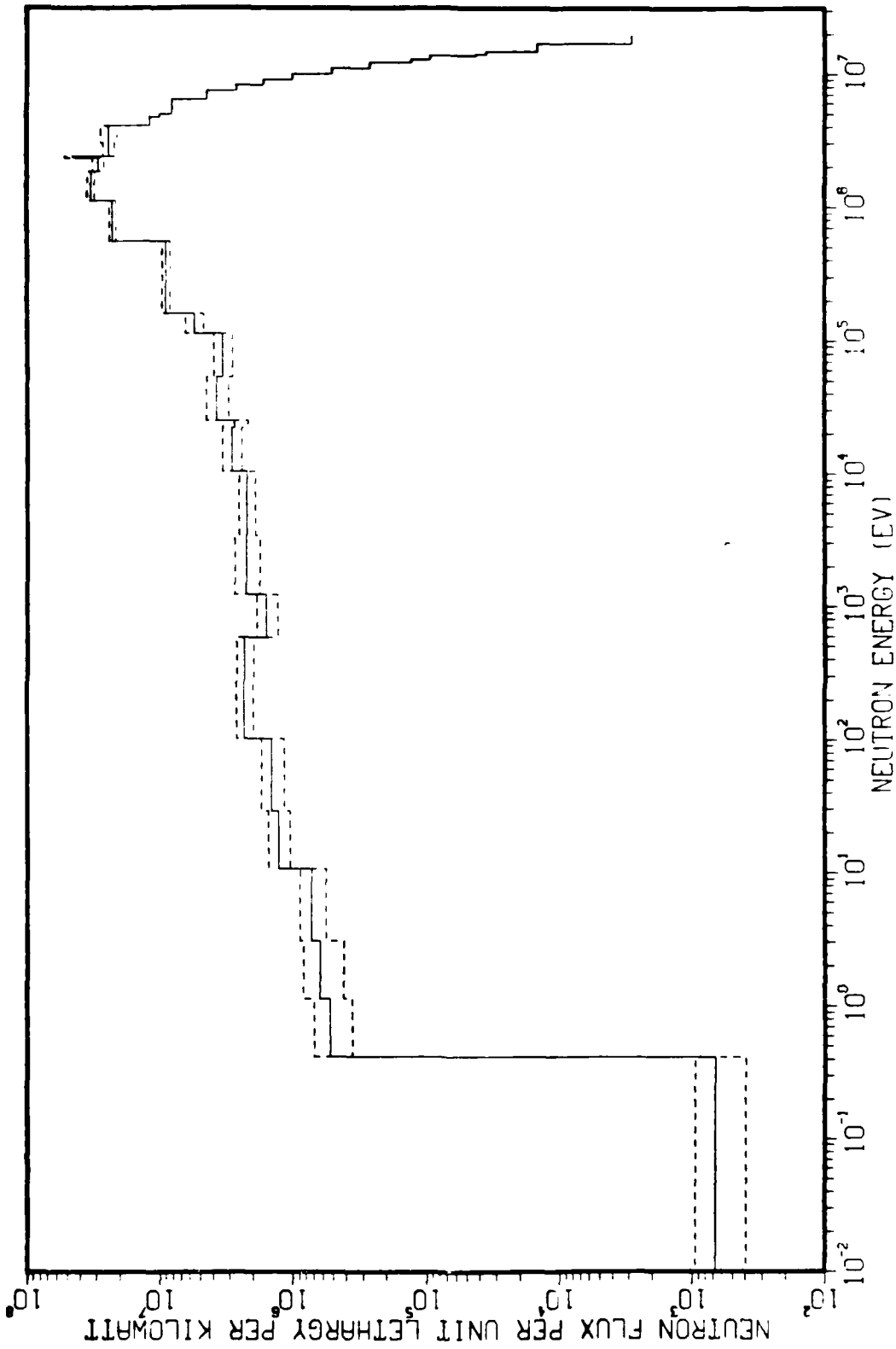

Figure II.4.20. Front Neutron Flux vs Energy ER1 with 2" Pb.

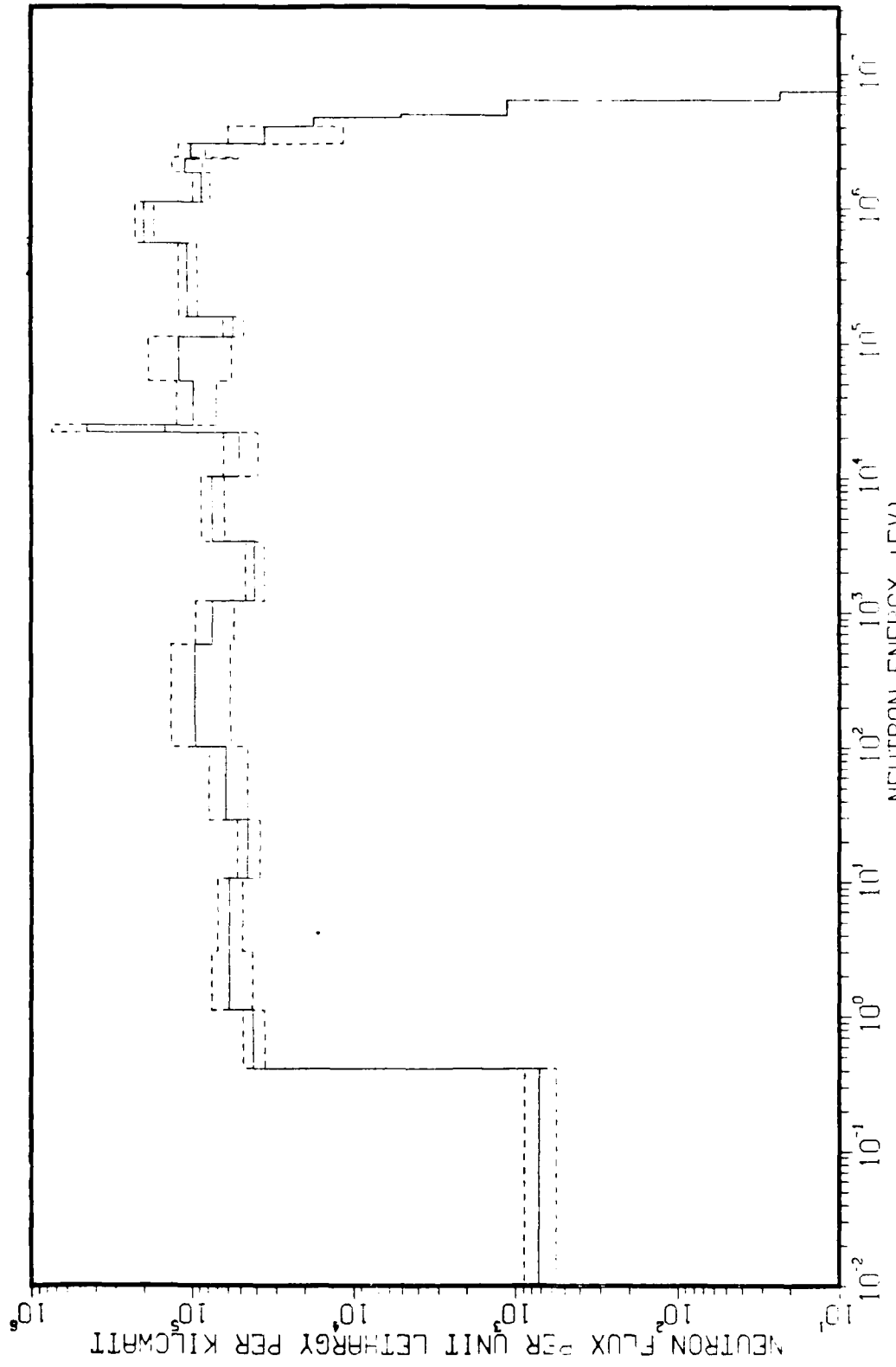

Figure II.4.21. Back Neutron Flux vs Energy ER1 with 2" Pb.

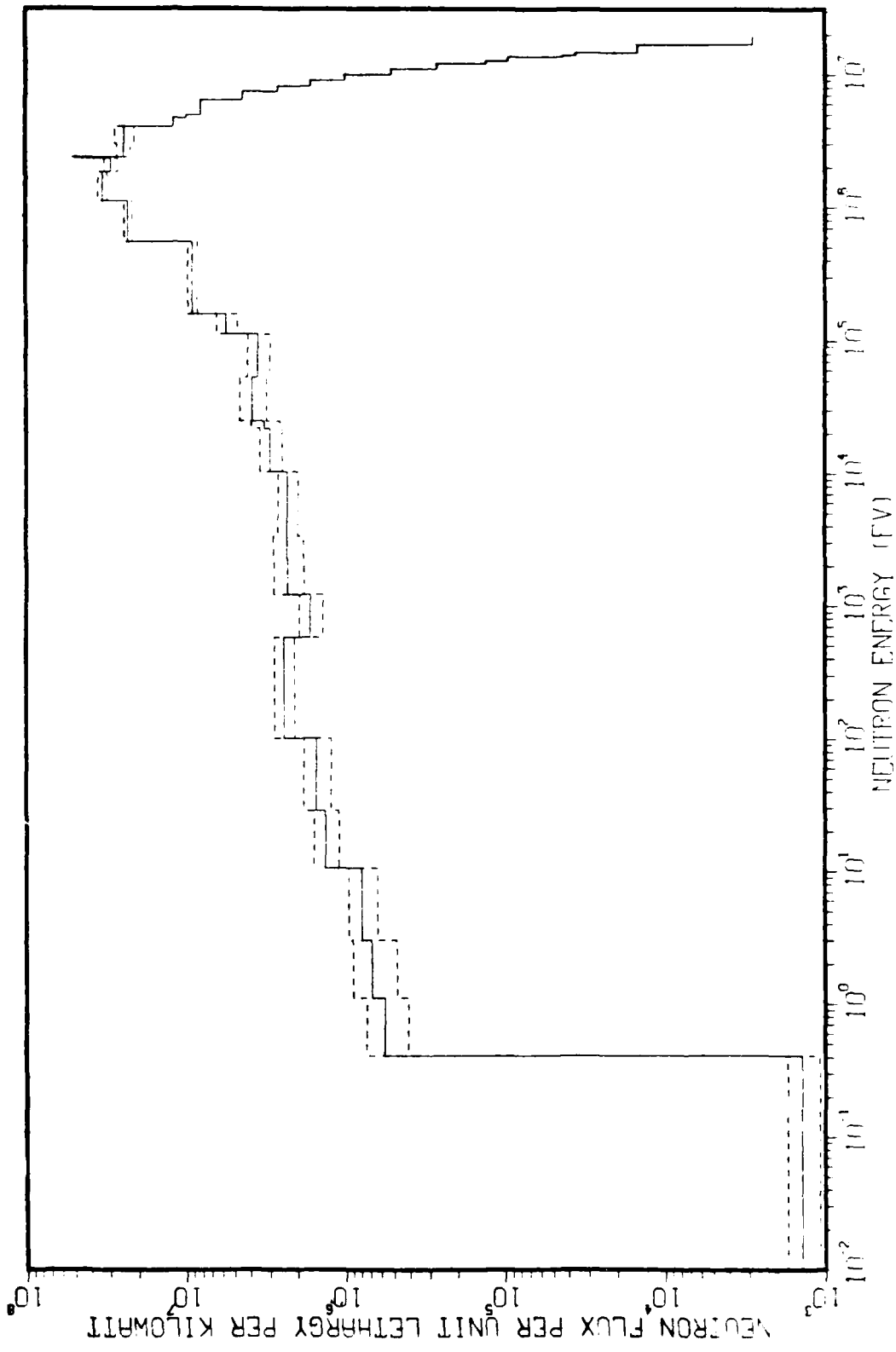

Figure II.4.22. Total (Front+Back) Neutron Flux vs Energy ERI with 2" Pb.

Table II.4.18. Neutron Flux per Unit Lethargy per Kilowatt.

ERI WITH 2 IN. PB

GROUP	ENERGY (EV)	FRONT	BACK	TOTAL
1	1.960E+07	2.82E+03	0.00E+00	2.82E+03
2	1.690E+07	1.48E+04	0.00E+00	1.48E+04
3	1.490E+07	3.61E+04	0.00E+00	3.61E+04
4	1.420E+07	4.32E+04	0.00E+00	4.32E+04
5	1.380E+07	9.51E+04	0.00E+00	9.51E+04
6	1.280E+07	1.31E+05	0.00E+00	1.31E+05
7	1.220E-07	2.68E+05	0.00E+00	2.68E+05
8	1.110E+07	5.18E+05	0.00E+00	5.18E+05
9	1.000E+07	1.01E+06	0.00E+00	1.01E+06
10	9.050E-06	1.66E+06	0.00E+00	1.66E+06
11	8.190E+06	2.66E+06	0.00E+00	2.66E+06
12	7.410E+06	4.42E+06	2.32E+01	4.42E+06
13	6.360E+06	8.05E+06	1.12E+03	8.05E+06
14	4.970E+06	9.95E+06	5.05E+03	9.96E+06
15	4.720E+06	1.19E+07	1.76E+04	1.19E+07
16	4.070E+06	2.43E+07 0.14	3.55E+04 0.67	2.43E+07 0.14
17	3.010E+06	2.44E+07 0.10	1.01E+05 0.18	2.45E+07 0.10
18	2.390E+06	4.38E+07 0.17	8.96E+04 0.43	4.39E+07 0.17
19	2.310E+06	2.94E+07 0.10	1.09E+05 0.22	2.95E+07 0.10
20	1.830E+06	3.32E+07 0.07	8.70E+04 0.12	3.33E+07 0.07
21	1.110E+06	2.28E+07 0.06	1.97E+05 0.13	2.30E+07 0.06
22	5.500E+05	9.03E+06 0.07	1.06E+05 0.13	9.14E+06 0.07
23	1.580E+05	5.54E+06 0.15	5.57E+04 0.15	5.60E+06 0.15
24	1.110E+05	3.41E+06 0.16	1.21E+05 0.53	3.53E+06 0.16
25	5.250E+04	3.76E+06 0.19	9.78E+04 0.28	3.85E+06 0.19
26	2.480E+04	2.77E+06 0.21	4.44E+05 0.67	3.22E+06 0.20
27	2.190E+04	2.92E+06 0.16	5.14E+04 0.24	2.97E+06 0.16
28	1.030E+04	2.24E+06 0.14	7.53E+04 0.16	2.32E+06 0.14
29	3.350E+03	2.28E+06 0.22	4.12E+04 0.13	2.32E+06 0.21
30	1.230E+03	1.60E+06 0.18	7.51E+04 0.27	1.67E+06 0.17
31	5.830E+02	2.35E+06 0.15	9.62E+04 0.40	2.45E+06 0.15
32	1.010E+02	1.47E+06 0.20	6.23E+04 0.26	1.53E+06 0.19
33	2.900E+01	1.30E+06 0.18	4.56E+04 0.16	1.35E+06 0.18
34	1.070E+01	7.37E+05 0.22	5.94E+04 0.17	7.97E+05 0.20
35	3.060E+00	6.33E+05 0.33	5.93E+04 0.28	6.92E+05 0.30
36	1.130E+00	5.31E+05 0.31	4.22E+04 0.15	5.73E+05 0.29
37	4.140E-01	6.76E+02 0.41	7.26E+02 0.23	1.40E+03 0.23

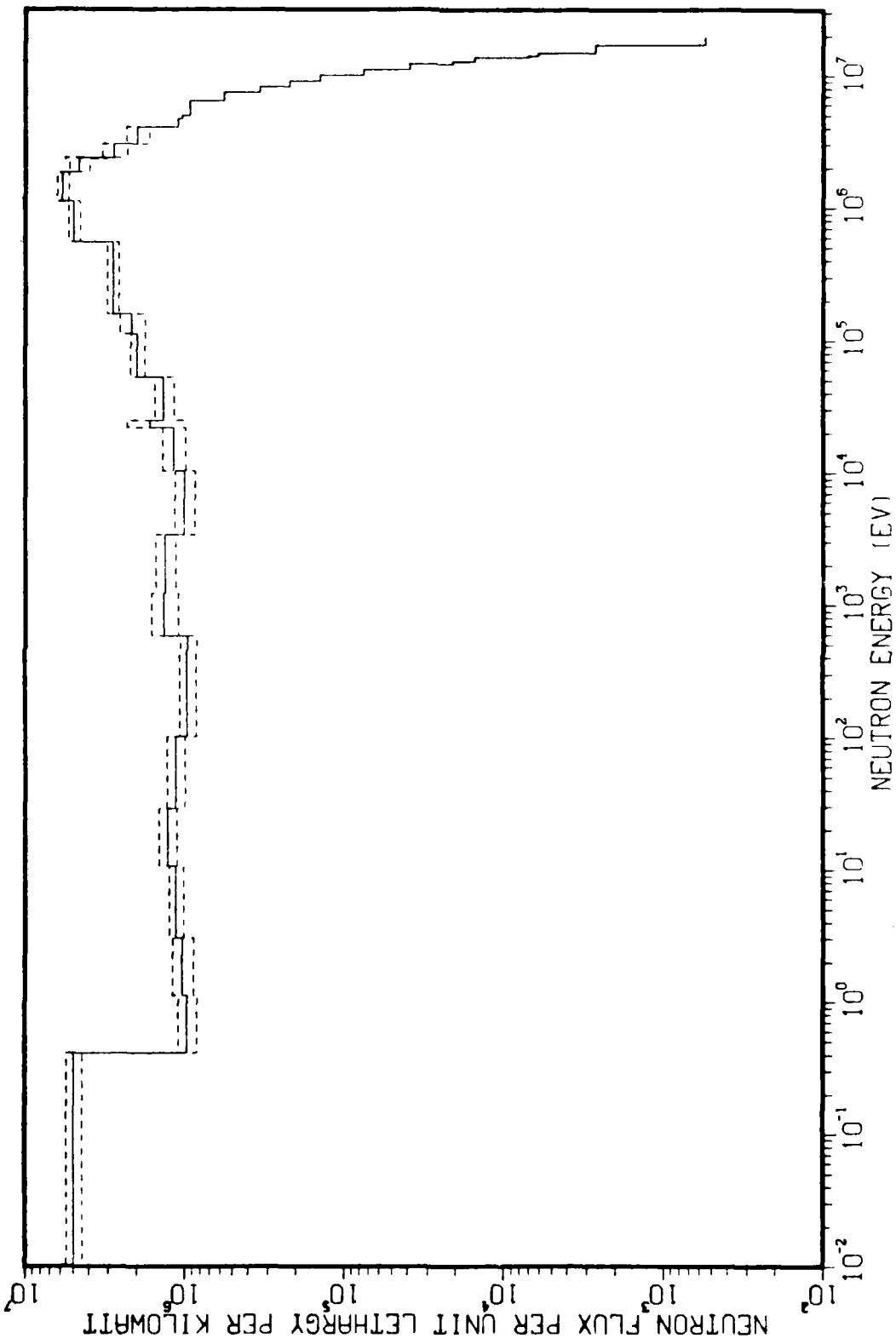

Figure II.4.23. Front (3-D) Neutron Flux vs Energy ER1 with 6" Pb and Phantom.

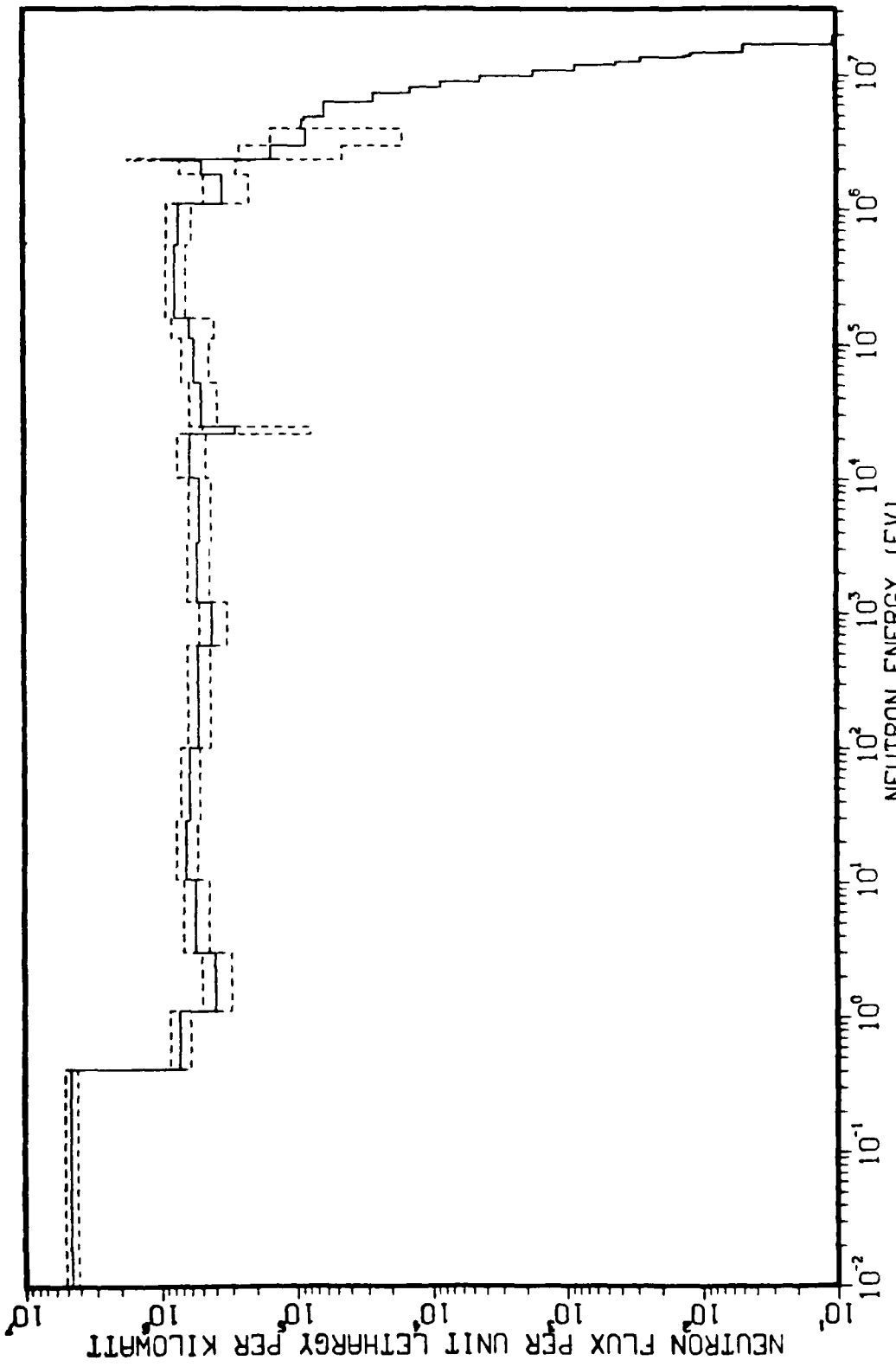

Figure II.4.24. Back (3-D) Neutron Flux vs Energy ER1 with 6" Pb and Phantom.

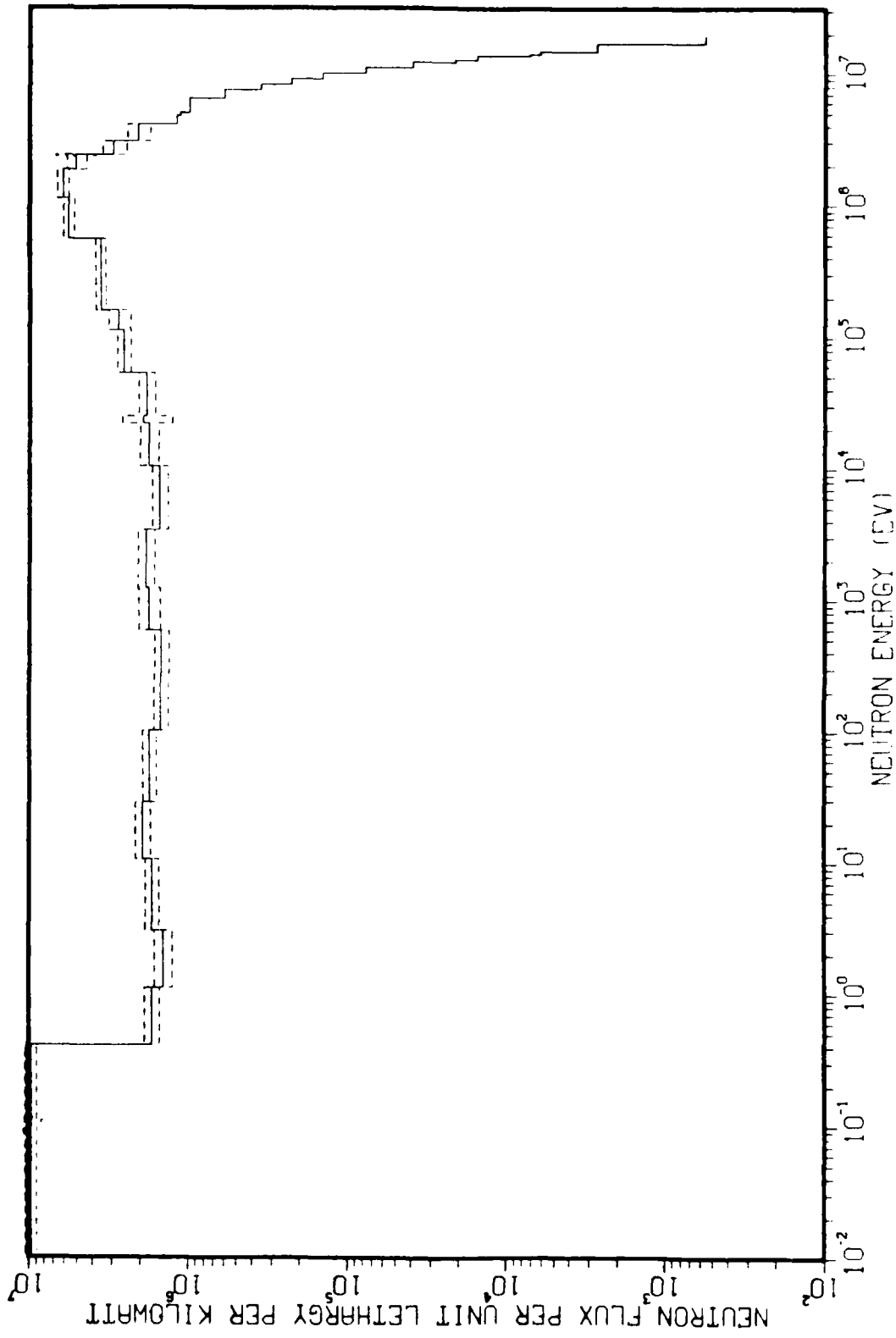

Figure II.4.25. Total (Front+Back) Neutron Flux vs Energy ER1 with 6" Pb and Phantom.

Table II.4.19. Neutron Flux per Unit Lethargy per Kilowatt.

GROUP	ENERGY (EV)	PHANTOM BEHIND 6" Pb WALL FRONT	BACK	TOTAL
1	1.960E+07	5.52E+02	1.04E+01	5.62E+02
2	1.690E+07	2.65E+03	4.85E+01	2.70E+03
3	1.490E+07	6.08E+03	1.18E+02	6.19E+03
4	1.420E+07	6.99E+03	1.31E+02	7.12E+03
5	1.380E+07	1.51E+04	2.76E+02	1.54E+04
6	1.280E+07	2.08E+04	4.20E+02	2.13E+04
7	1.220E+07	3.88E+04	8.42E+02	3.97E+04
8	1.110E+07	7.59E+04	1.72E+03	7.76E+04
9	1.000E+07	1.42E+05	4.25E+03	1.46E+05
10	9.050E+06	2.20E+05	8.29E+03	2.28E+05
11	8.190E+06	3.41E+05	1.38E+04	3.55E+05
12	7.410E+06	5.69E+05	2.60E+04	5.95E+05
13	6.380E+06	9.32E+05	6.03E+04	9.92E+05
14	4.970E+06	1.05E+06	8.56E+04	1.13E+06
15	4.720E+06	1.11E+06	8.97E+04	1.20E+06
16	4.070E+06	2.01E+06 0.16	8.36E+04 0.81	2.09E+06 0.16
17	3.010E+06	2.82E+06 0.18	1.50E+05 0.70	2.97E+06 0.17
18	2.390E+06	4.39E+06 0.29	9.67E+05 0.78	5.36E+06 0.28
19	2.310E+06	4.64E+06 0.14	4.90E+05 0.44	5.13E+06 0.14
20	1.830E+06	5.87E+06 0.08	3.45E+05 0.36	6.21E+06 0.08
21	1.110E+06	4.97E+06 0.08	7.28E+05 0.21	5.70E+06 0.07
22	5.500E+05	2.84E+06 0.08	7.68E+05 0.16	3.61E+06 0.07
23	1.580E+05	2.17E+06 0.18	6.04E+05 0.35	2.77E+06 0.16
24	1.110E+05	1.99E+06 0.11	5.60E+05 0.23	2.55E+06 0.10
25	5.250E+04	1.36E+06 0.14	4.90E+05 0.23	1.85E+06 0.12
26	2.480E+04	1.66E+06 0.38	2.78E+05 0.72	1.94E+06 0.34
27	2.190E+04	1.18E+06 0.16	6.03E+05 0.24	1.79E+06 0.13
28	1.030E+04	1.01E+06 0.15	5.14E+05 0.18	1.53E+06 0.12
29	3.350E+03	1.34E+06 0.14	5.29E+05 0.18	1.87E+06 0.11
30	1.230E+03	1.37E+06 0.19	4.18E+05 0.23	1.78E+06 0.16
31	5.830E+02	9.67E+05 0.12	5.26E+05 0.19	1.49E+06 0.10
32	1.010E+02	1.15E+06 0.13	6.10E+05 0.16	1.76E+06 0.10
33	2.900E+01	1.29E+06 0.13	6.45E+05 0.17	1.93E+06 0.10
34	1.070E+01	1.14E+06 0.10	5.55E+05 0.21	1.69E+06 0.10
35	3.060E+00	1.04E+06 0.15	3.96E+05 0.24	1.44E+06 0.13
36	1.130E+00	9.68E+05 0.14	7.25E+05 0.17	1.69E+06 0.11
37	4.140E-01	4.98E+06 0.11	4.63E+06 0.10	9.60E+06 0.08

5. COMPARISON OF 1-D AND 3-D RESULTS

The rather laborious task of comparing the 1-D and 3-D spectra and responses, group by group and case by case is left to the reader. It is, however, worth mentioning that the 1-D and 3-D results agree remarkably well for all but two cases. Considering the far from spherical nature of some of these configurations, it is extraordinary to find the ANISN results agreeing well not only in spectral shape but magnitude as well. The cases which did not agree quite as well, as ascertained by visual inspection as well as differences in the unfolding process, were the ones which one would expect. Namely the cases with exercize wheel and the phantom, both of which contain complex shapes (from a spherical modeling point of view) of hydrogenous material in which neutrons scatter readily. In both of these cases, the unfolding process indicated that the spliced spectra were more correct than the 1-D spectra. This is as one would hope and expect, since the 3-D model should more accurately reflect the true physical configuration. One may therefore conclude that 1-D calculations are adequate except in cases where complex shapes of hydrogenous material are located near the detector(s).

6. FREE FIELD SPECTRA AS A FUNCTION OF DISTANCE FROM THE REACTOR IN ER1 AND ER2

In addition to knowing the neutron and gamma-ray spectra near the reactor tank it is of interest to know the radiation fields further away. The knowledge of the effects on the free field fluxes from perturbations in the room and reactor configuration, coupled with the knowledge of the dependence of the free field flux as a function of position in the room, should allow reasonable estimates to be made of the flux for a wide variety of experimental arrangements. Thus, an effort was made to calculate the free field flux in ER1 and ER2 as a function of distance from the reactor center.

From the agreement between the 1-D and 3-D results for the free field cases it was clear that this could be done using the ANISN model. It was not clear, however, that this would hold for cases very deep in the room where wall effects could be important. Therefore a MORSE run was made with the detector located 290 cms from the reactor center in ER2 and the results compared with a similar ANISN calculation. The spectra resulting from these two calculations are shown in Figures II.6.1 through II.6.6. The good agreement in shape and magnitude, even at this depth in the room (1.37 meters from the back wall), indicates that 3-D runs are not necessary.

The results for ER1 are shown in Figures II.6.7 through II.6.42 and Tables II.6.1 through II.6.12 for distances of 50, 100, 200, 300, 400, and 500 cms into ER1. In addition, Tables II.6.13 through II.6.15 show the front, back, and total components of the nine integral responses as a function of distance into the room. The results for ER2 are shown in Figures II.6.43 through II.6.66 and Tables II.6.16 through II.6.23 for distances of 50, 100, 200, and 300 cms from the reactor. Tables II.6.24 through II.6.26 show the responses as a function of distance into ER2.

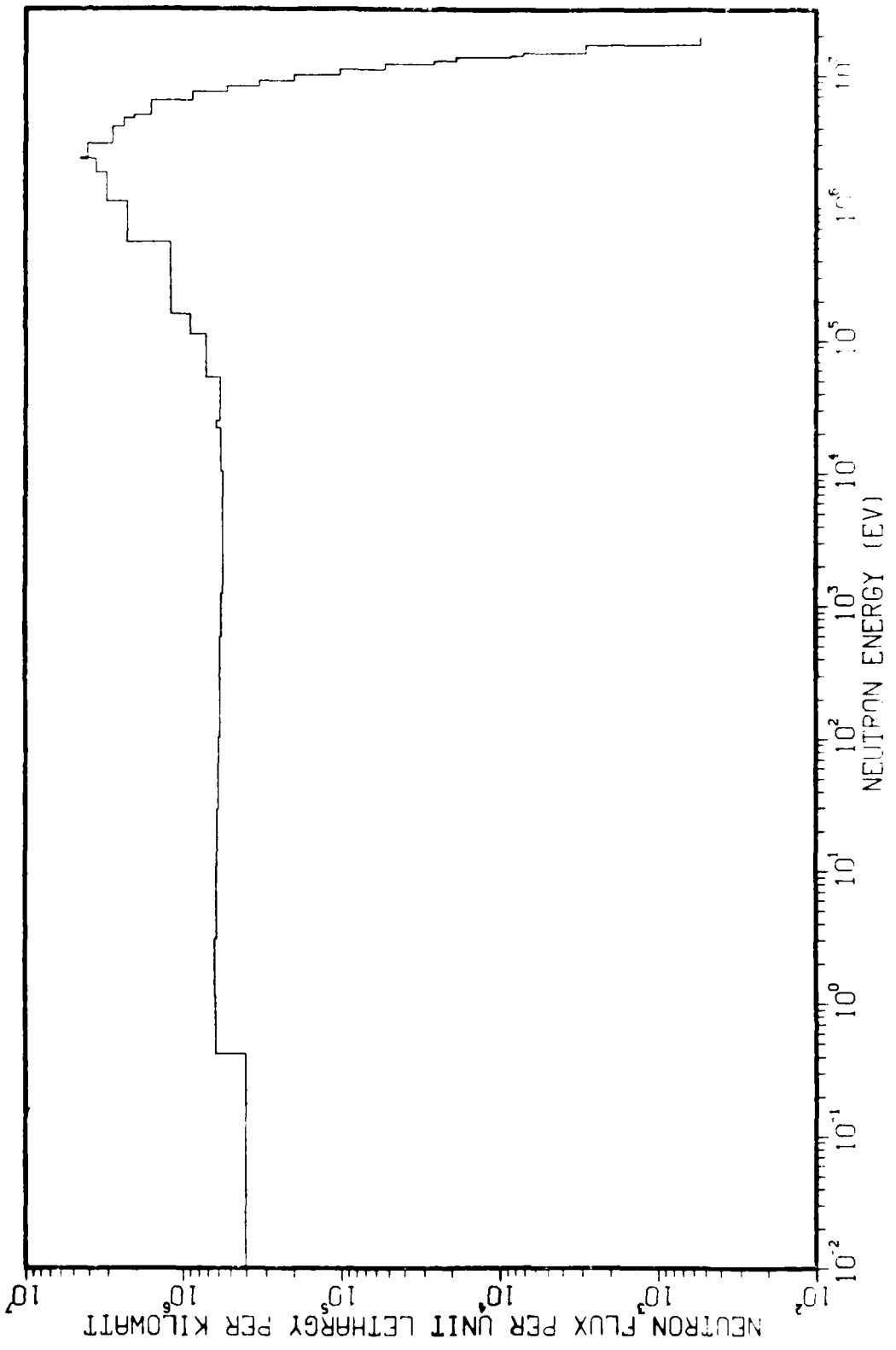

Figure II.6.1. Front Neutron Flux vs Energy - Free Field ER1 290.51 CMS from Reactor (1-D).

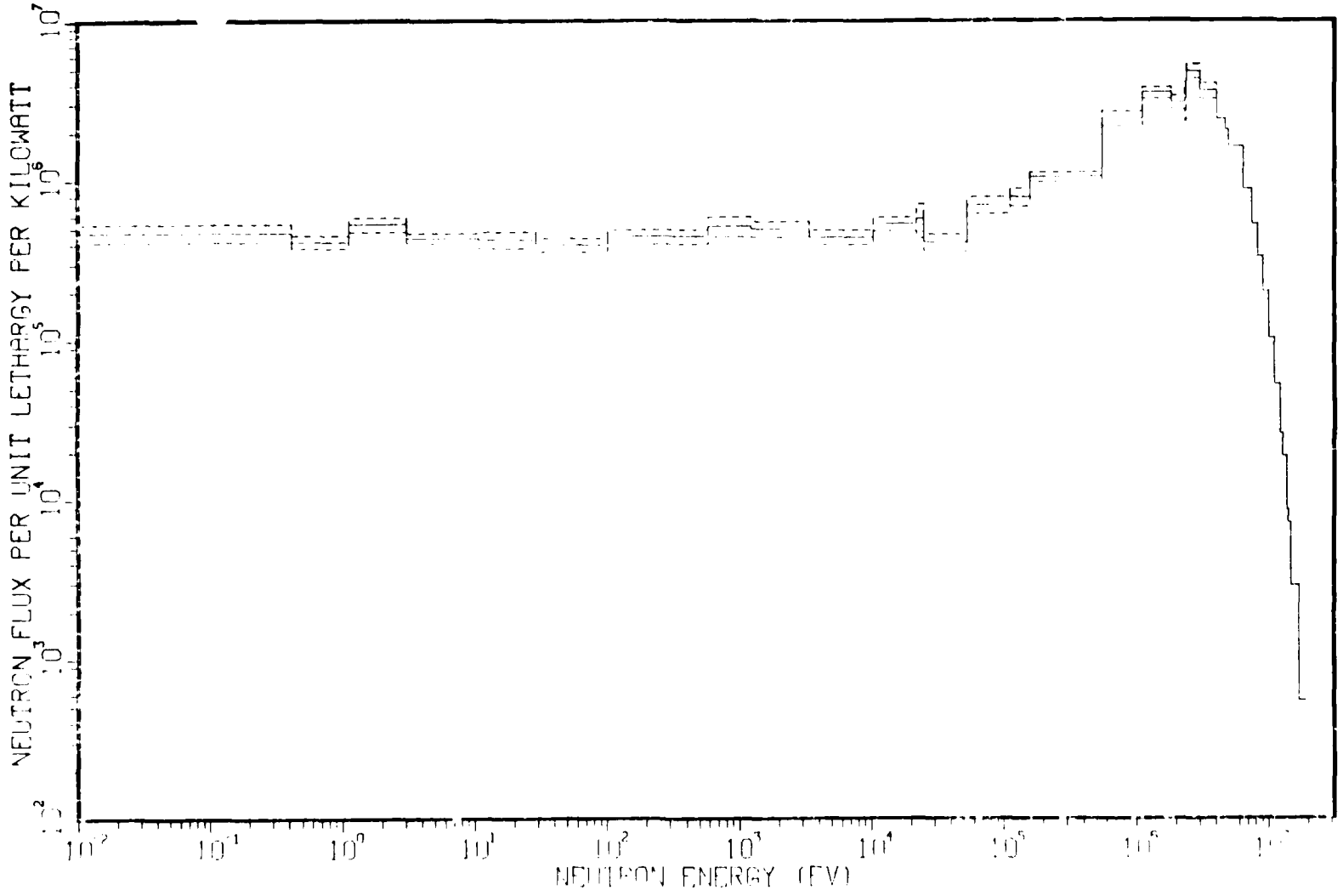

Figure II.6.2. Front Neutron Flux vs Energy - Free Field ER1 290.51 CMS from Reactor (3-D).

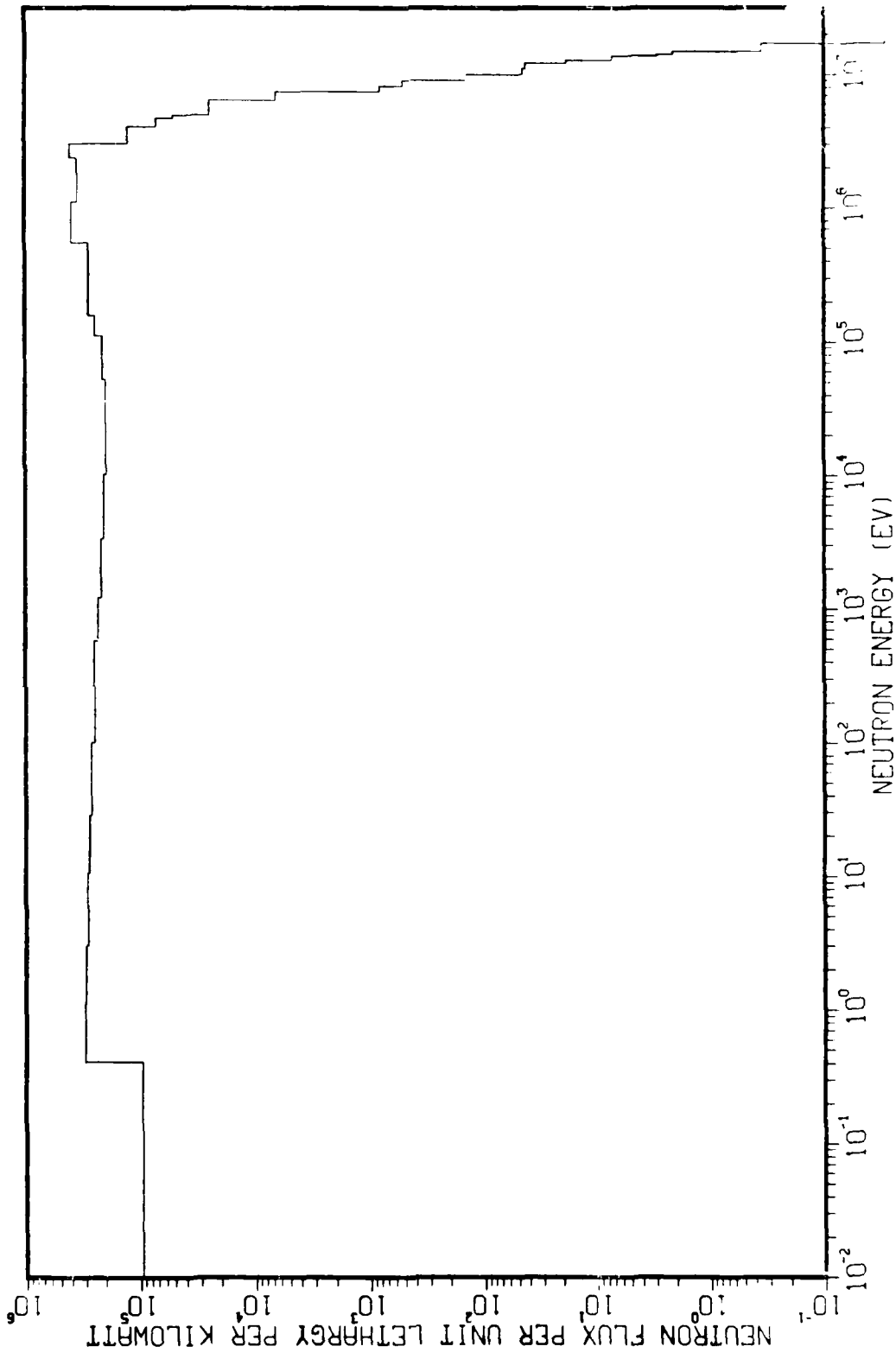

Figure II.6.3. Back Neutron Flux vs Energy - Free Field ERI 290.51 CMS from Reactor (1-D).

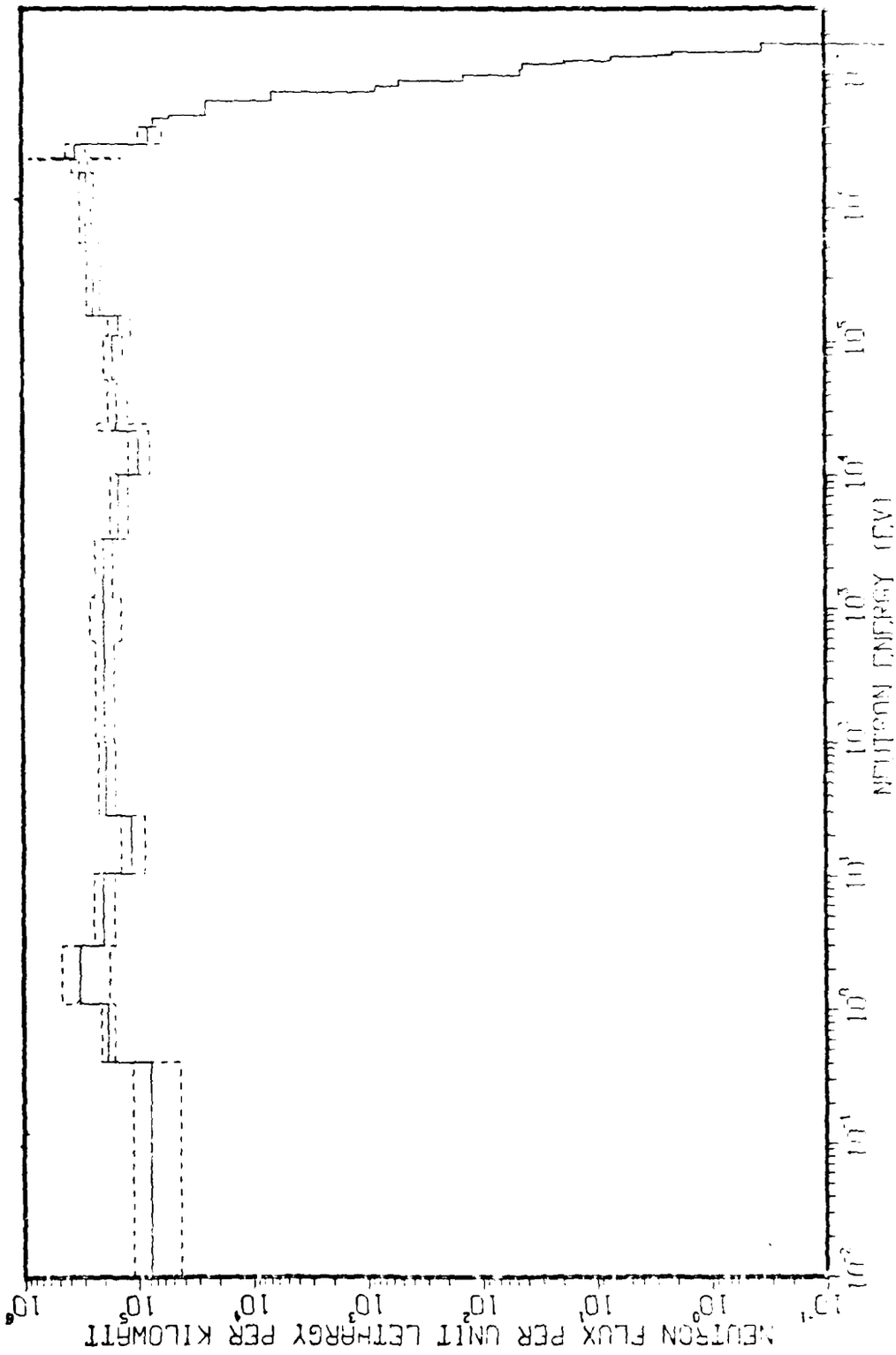

Figure 11.6.4. Back Neutron Flux vs Energy - Free Field ERI 290.51 CMS from Reactor (3-D).

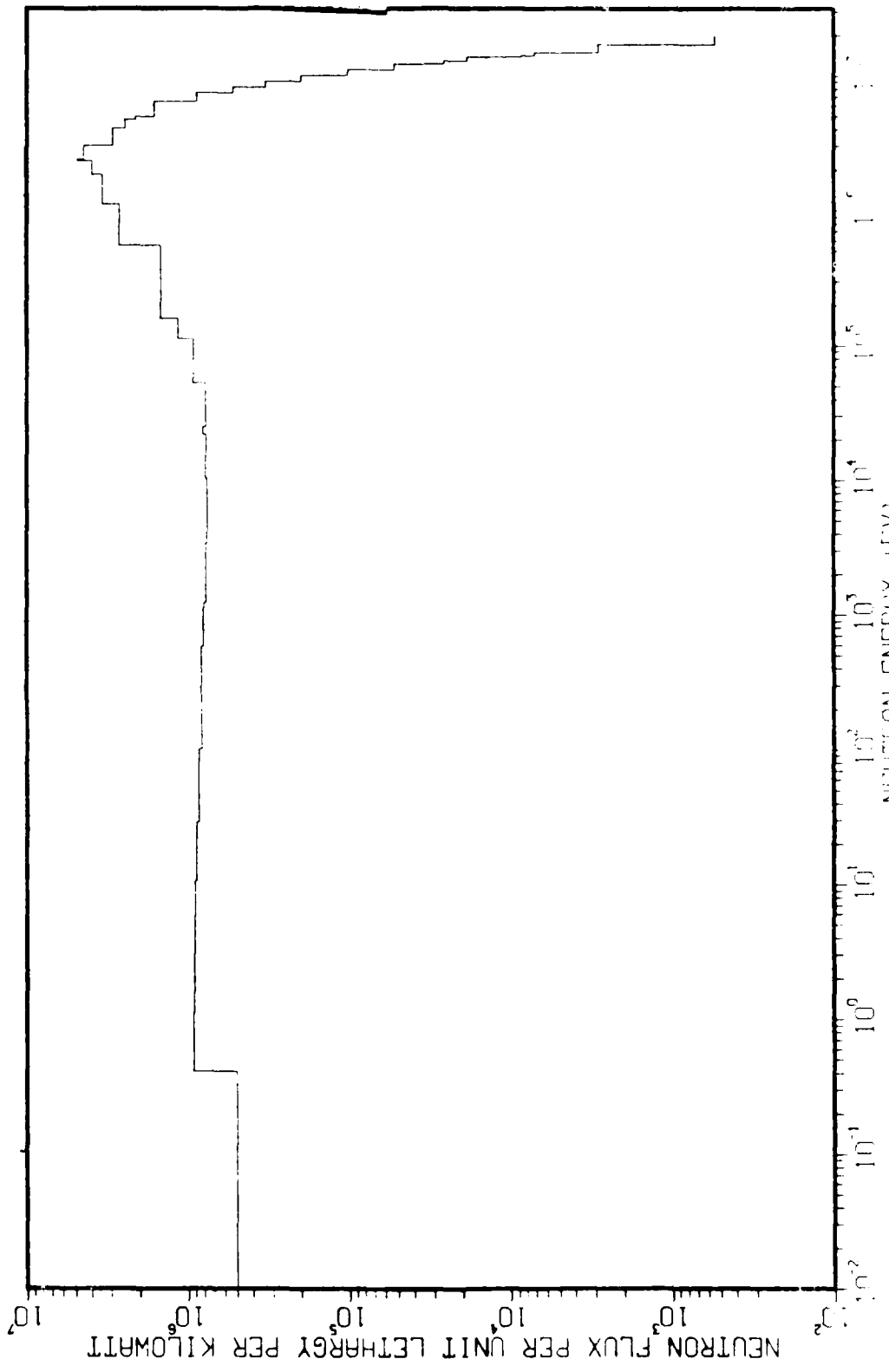

Figure II.6.5. Total Neutron Flux vs Energy - Free Field ERI 290.51 CMS from Reactor (1-D).

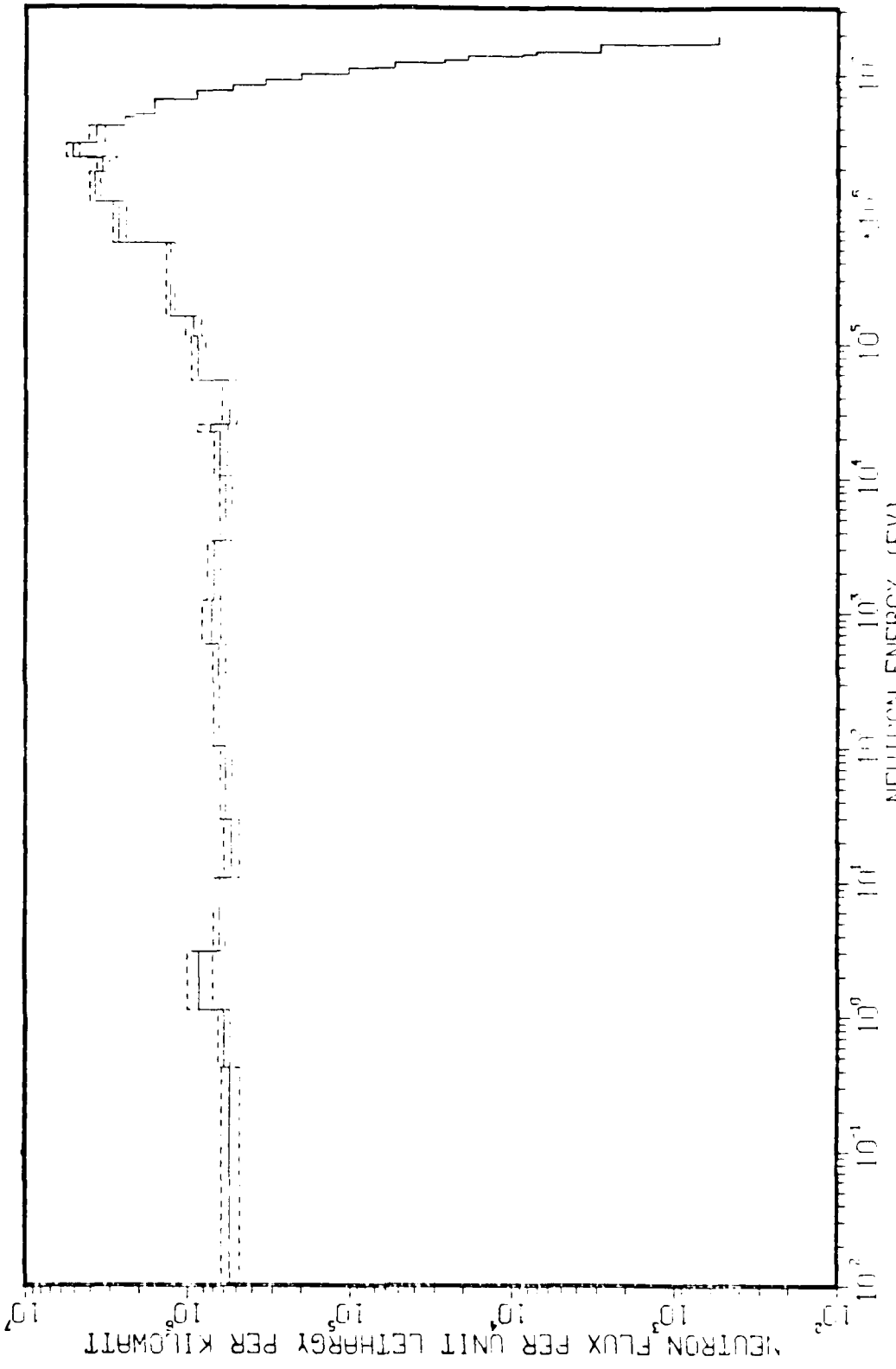

Figure II.6.6. Total Neutron Flux vs Energy - Free Field ER1 290.51 CMS from Reactor (3-D).

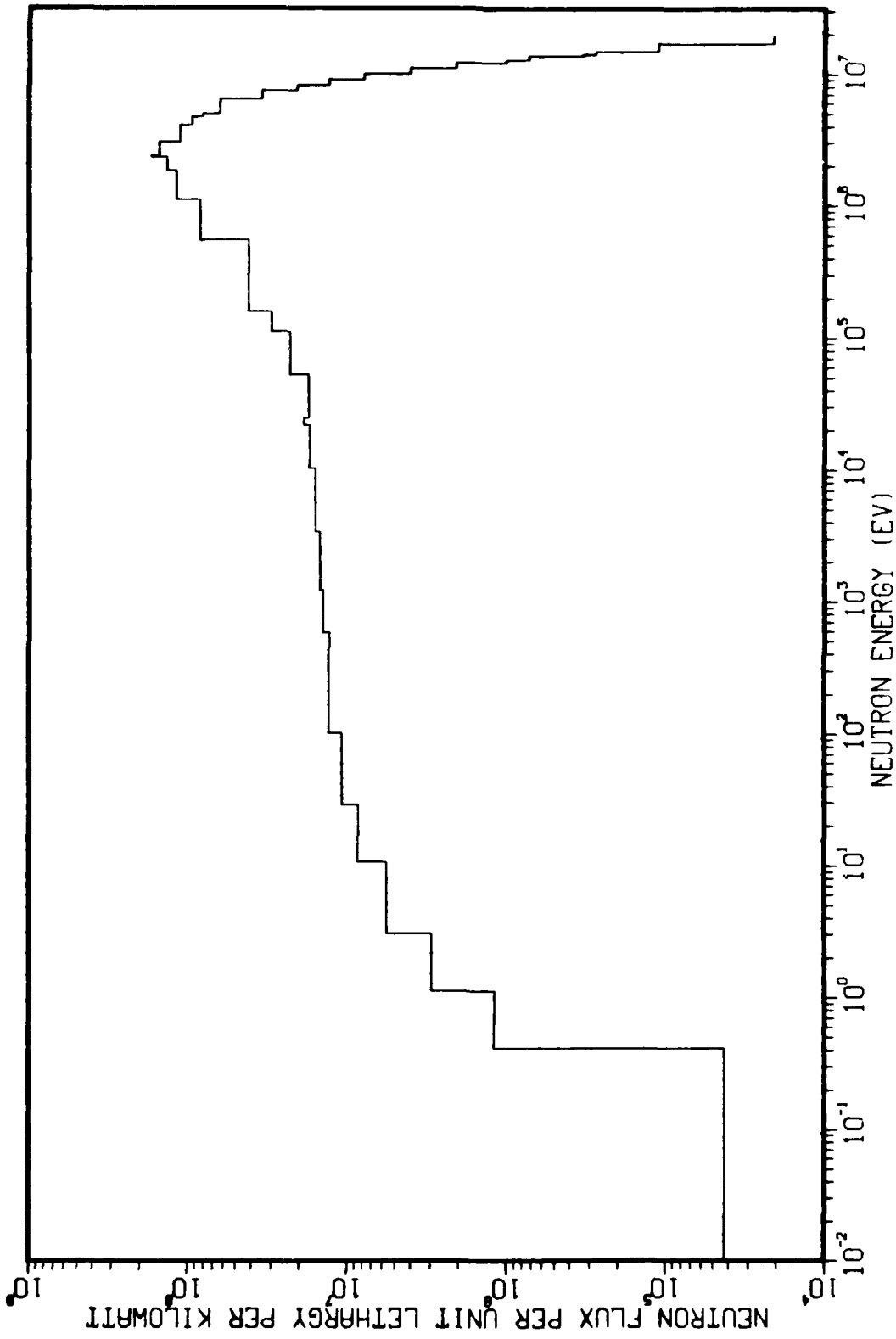

Figure II.6.7. Front Neutron Flux vs Energy Free Field ER1 50 CMS from Reactor.

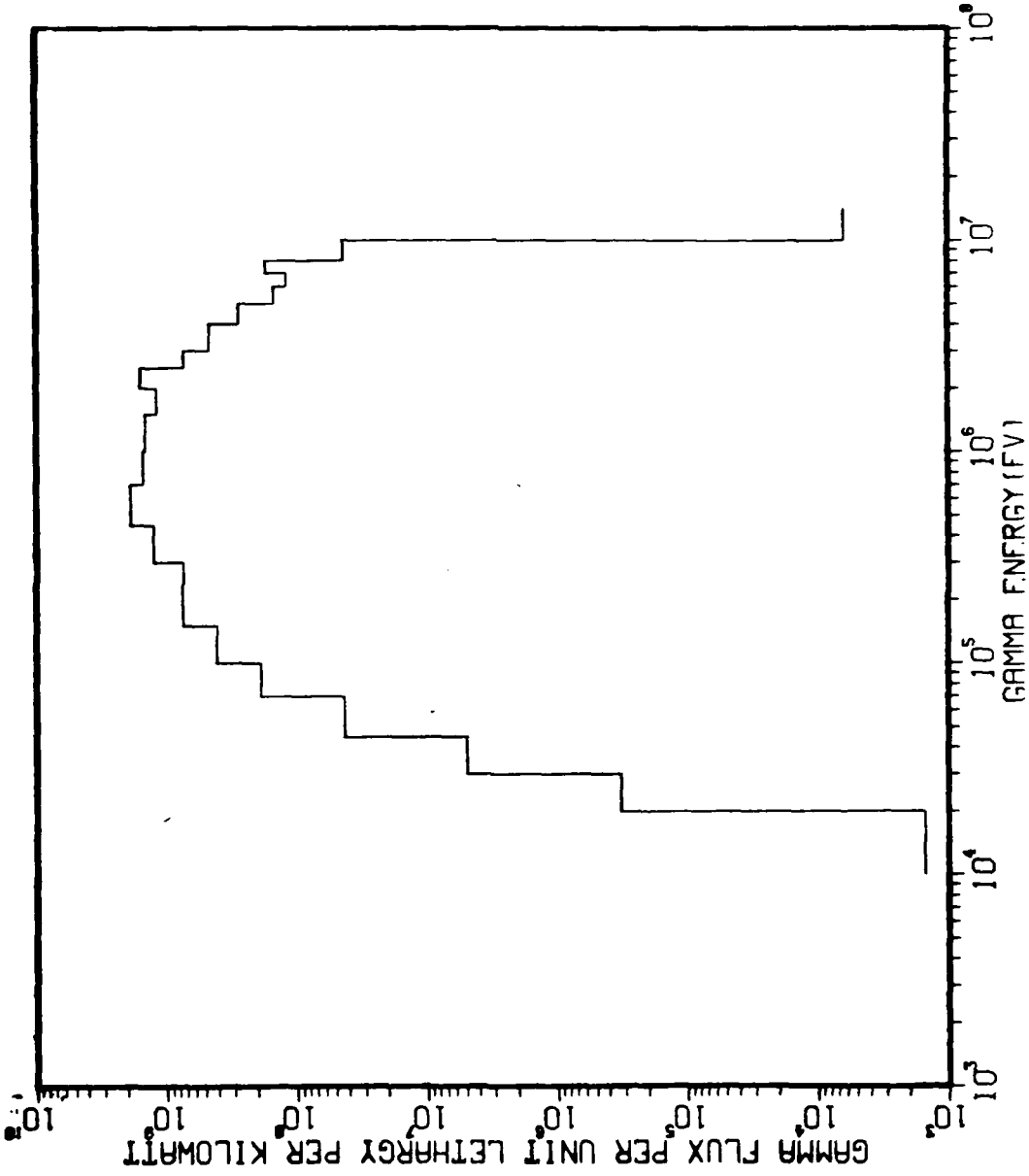

Figure II.6.8. Front Gamma Flux vs Energy Free Field ER1 50 CMS from Reactor.

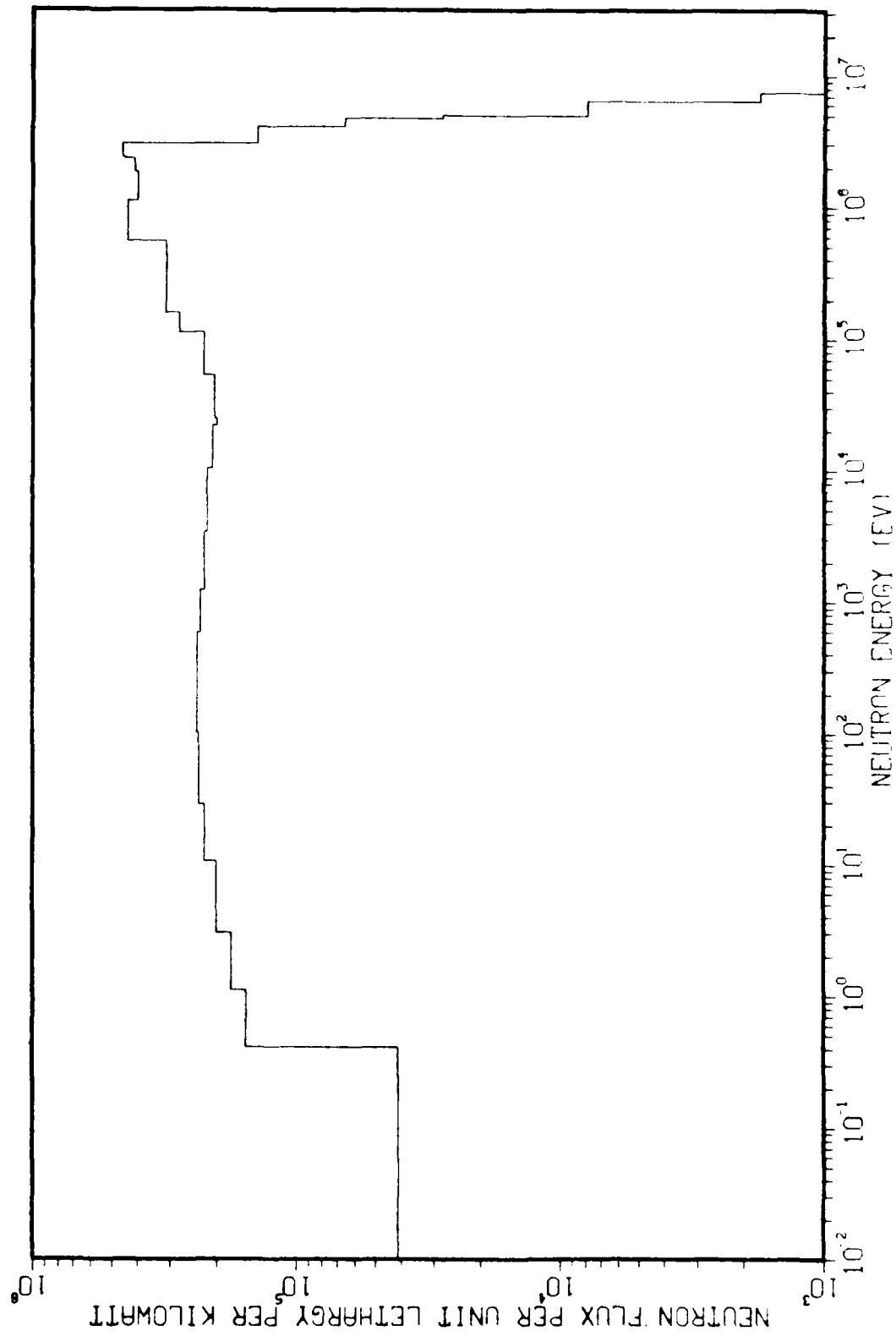

Figure II.6.9. Back Neutron Flux vs Energy Free Field ER1 50 CMS from Reactor.

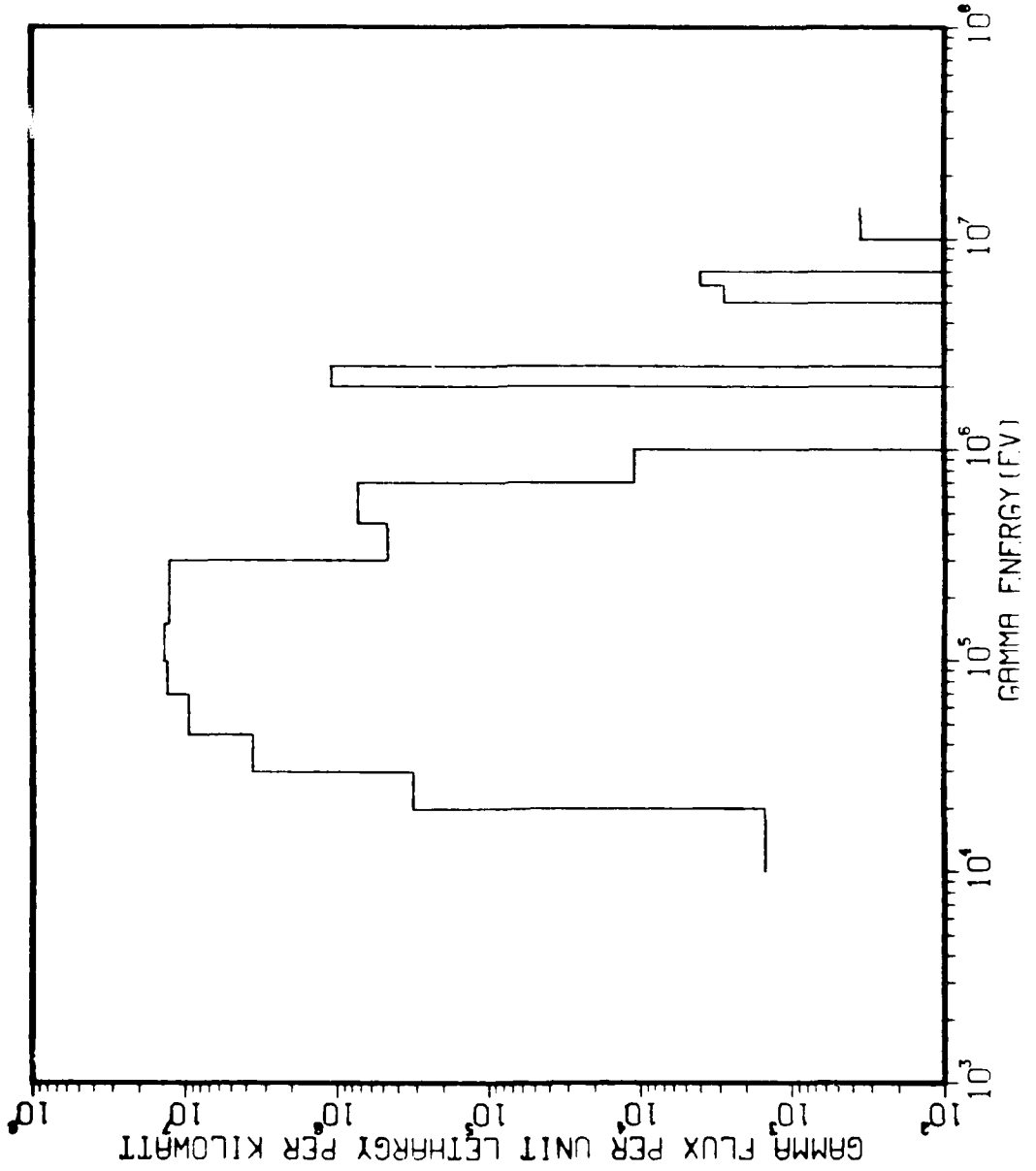

Figure II.6.10. Back Gamma Flux vs Energy Free Field ER1 50 CMS from Reactor.

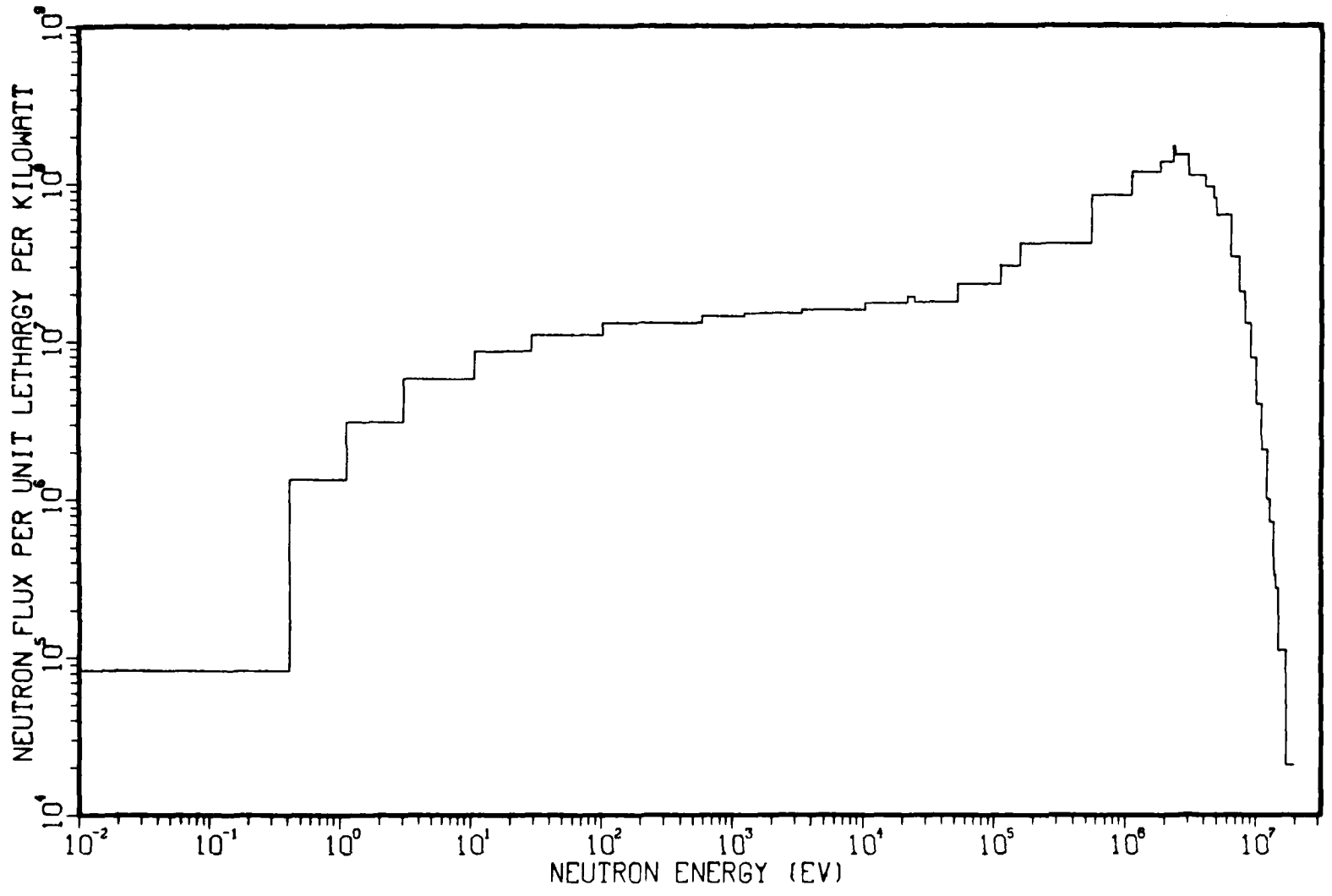

Figure II.6.11. Total Neutron Flux vs Energy Free Field ER1 50 CMS from Reactor.

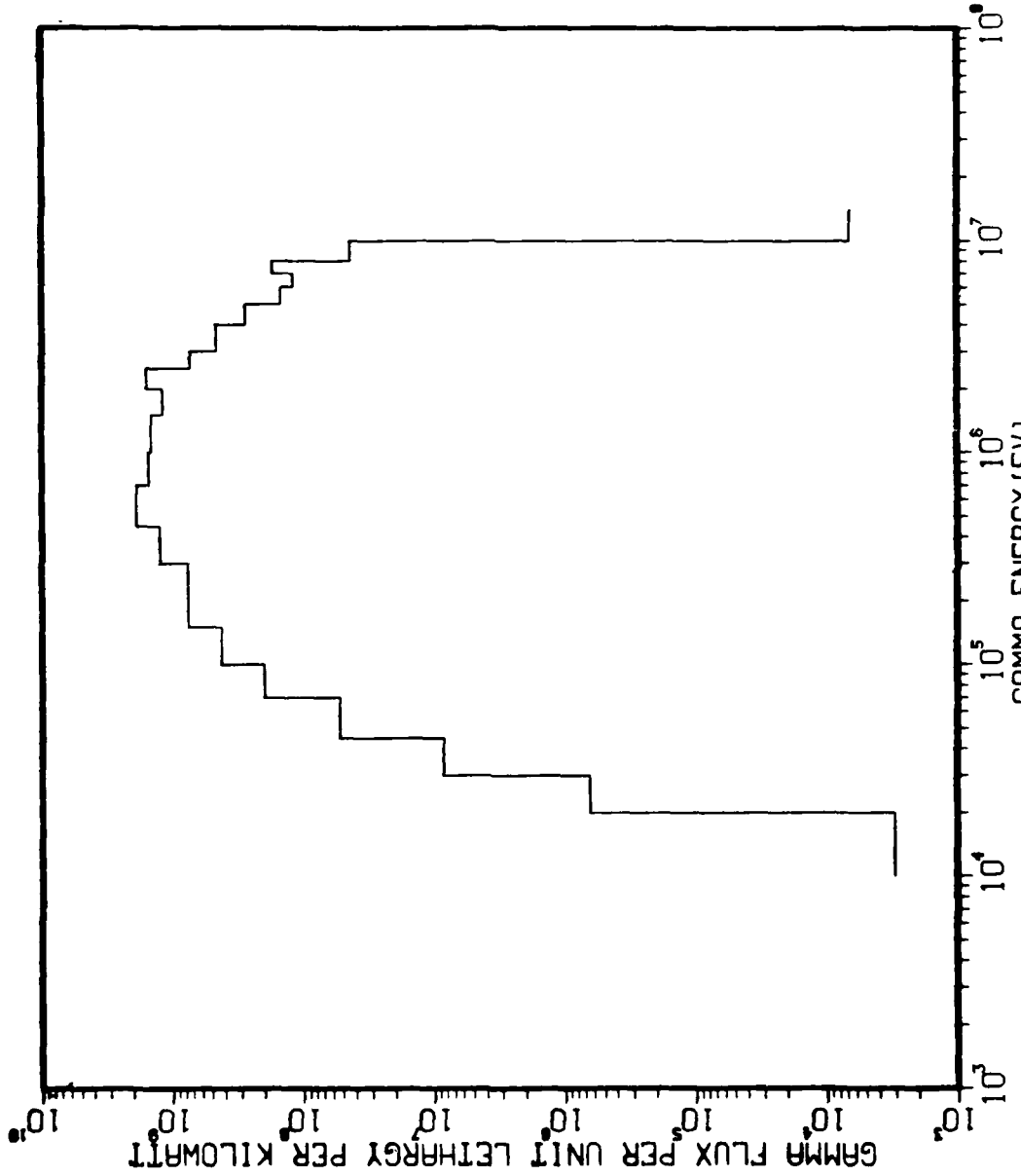

Figure II.6.12. Total Gamma Flux vs Energy Free Field ER1 50 CMS from Reactor.

Table II.6.1. Neutron Flux per Unit Lethargy per Kilowatt.

ER1 FREE FIELD 50 CMS FROM REACTOR

GROUP	ENERGY (EV)	FRONT	BACK	TOTAL
1	1.960E+07	2.10E+04	0.00E+00	2.10E+04
2	1.690E+07	1.12E+05	0.00E+00	1.12E+05
3	1.490E+07	2.77E+05	0.00E+00	2.77E+05
4	1.420E+07	3.33E+05	0.00E+00	3.33E+05
5	1.380E+07	7.32E+05	0.00E+00	7.32E+05
6	1.280E+07	1.02E+06	0.00E+00	1.02E+06
7	1.220E+07	2.08E+06	0.00E+00	2.08E+06
8	1.110E+07	4.03E+06	0.00E+00	4.03E+06
9	1.000E+07	7.85E+06	0.00E+00	7.85E+06
10	9.050E+06	1.30E+07	0.00E+00	1.30E+07
11	8.190E+06	2.08E+07	0.00E+00	2.08E+07
12	7.410E+06	3.44E+07	1.76E+03	3.44E+07
13	6.380E+06	6.30E+07	7.94E+03	6.30E+07
14	4.970E+06	8.06E+07	2.81E+04	8.06E+07
15	4.720E+06	9.47E+07	6.56E+04	9.47E+07
16	4.070E+06	1.12E+08	1.41E+05	1.12E+08
17	3.010E+06	1.51E+08	4.54E+05	1.51E+08
18	2.390E+06	1.70E+08	4.45E+05	1.71E+08
19	2.810E+06	1.35E+08	4.10E+05	1.36E+08
20	1.830E+06	1.17E+08	3.98E+05	1.18E+08
21	1.110E+06	8.40E+07	4.34E+05	8.45E+07
22	5.500E+05	4.16E+07	3.12E+05	4.19E+07
23	1.580E+05	3.02E+07	2.77E+05	3.04E+07
24	1.110E+05	2.30E+07	2.25E+05	2.33E+07
25	5.250E+04	1.76E+07	2.05E+05	1.78E+07
26	2.480E+04	1.90E+07	2.02E+05	1.92E+07
27	2.190E+04	1.75E+07	2.09E+05	1.77E+07
28	1.030E+04	1.58E+07	2.17E+05	1.61E+07
29	3.350E+03	1.49E+07	2.24E+05	1.52E+07
30	1.230E+03	1.44E+07	2.32E+05	1.46E+07
31	5.830E+02	1.30E+07	2.37E+05	1.32E+07
32	1.010E+02	1.08E+07	2.34E+05	1.11E+07
33	2.900E+01	8.52E+06	2.23E+05	8.74E+06
34	1.070E+01	5.65E+06	2.01E+05	5.85E+06
35	3.060E+00	2.96E+06	1.77E+05	3.13E+06
36	1.130E+00	1.19E+06	1.55E+05	1.35E+06
37	4.140E-01	4.25E+04	4.10E+04	8.35E+04

Table II.6.2. Gamma Flux per Unit Lethargy per Kilowatt.

ERI FREE FIELD 60 CMS FROM REACTOR

GROUP	ENERGY (EV)	FRONT	BACK	TOTAL
1	1.400E+07	6.31E+03	3.53E+02	6.66E+03
2	1.000E+07	4.42E+07	0.00E+00	4.42E+07
3	8.000E+06	1.74E+08	0.00E+00	1.74E+08
4	7.000E+06	1.22E+08	4.02E+03	1.22E+08
5	6.000E+06	1.50E+08	2.79E+03	1.50E+08
6	5.000E+06	2.81E+08	0.00E+00	2.81E+08
7	4.000E+06	4.69E+08	0.00E+00	4.69E+08
8	3.000E+06	7.49E+08	0.00E+00	7.49E+08
9	2.500E+06	1.59E+09	1.08E+06	1.59E+09
10	2.000E+06	1.21E+09	0.00E+00	1.21E+09
11	1.500E+06	1.46E+09	0.00E+00	1.46E+09
12	1.000E+06	1.54E+09	1.09E+04	1.54E+09
13	7.000E+05	1.89E+09	7.23E+05	1.89E+09
14	4.500E+05	1.27E+09	4.69E+05	1.27E+09
15	3.000E+05	7.56E+08	1.27E+07	7.68E+08
16	1.500E+05	4.11E+08	1.35E+07	4.25E+08
17	1.000E+05	1.88E+08	1.30E+07	2.01E+08
18	7.000E+04	4.35E+07	9.45E+06	5.30E+07
19	4.500E+04	4.96E+06	3.57E+06	8.54E+06
20	3.000E+04	3.26E+05	3.14E+05	6.40E+05
21	2.000E+04	1.51E+03	1.51E+03	3.02E+03

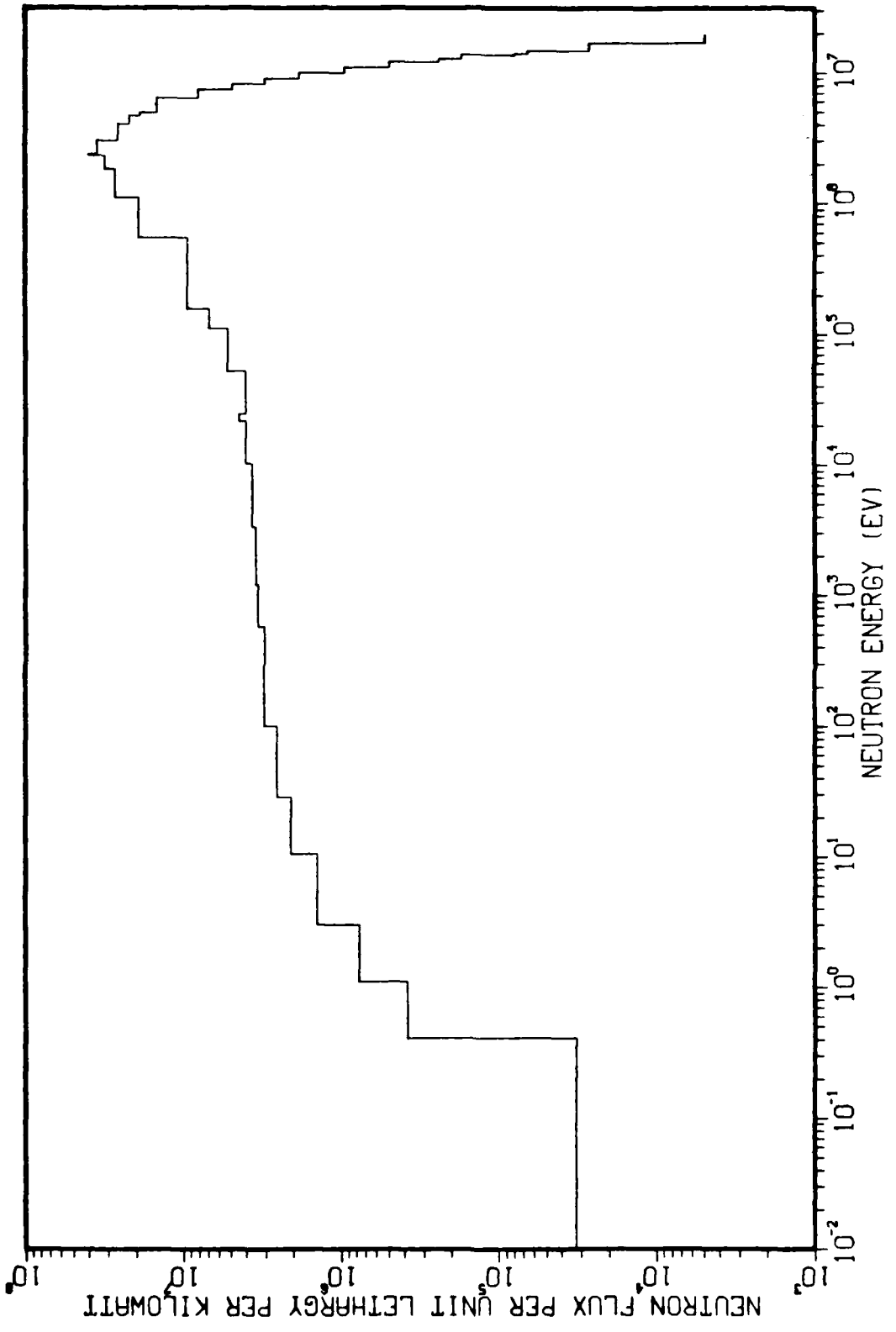

Figure II.6.13. Front Neutron Flux vs Energy Free Field ER1 100 CMS from Reactor.

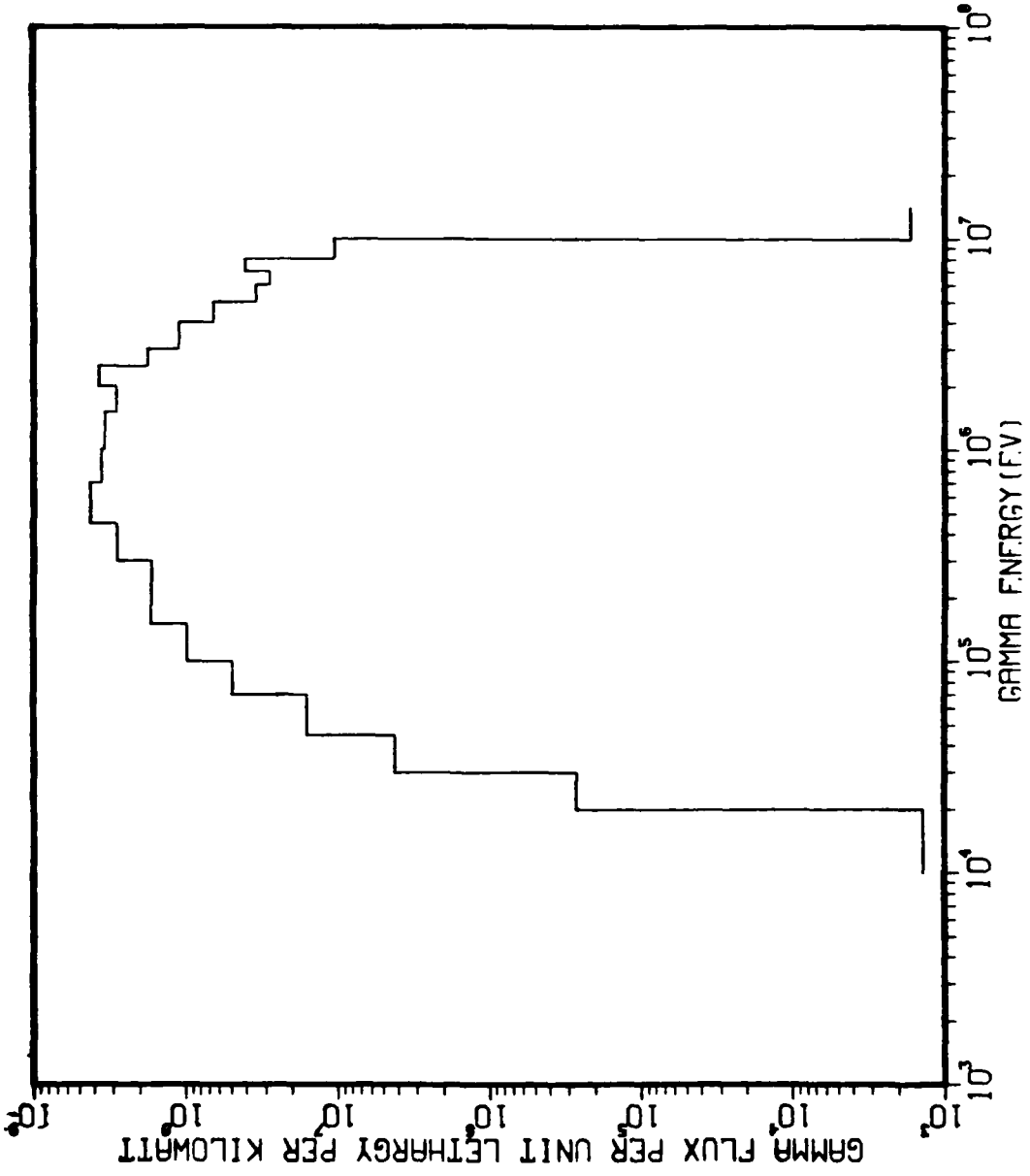

Figure II.6.14. Front Gamma Flux vs Energy Free Field ER1 100 CMS from Reactor.

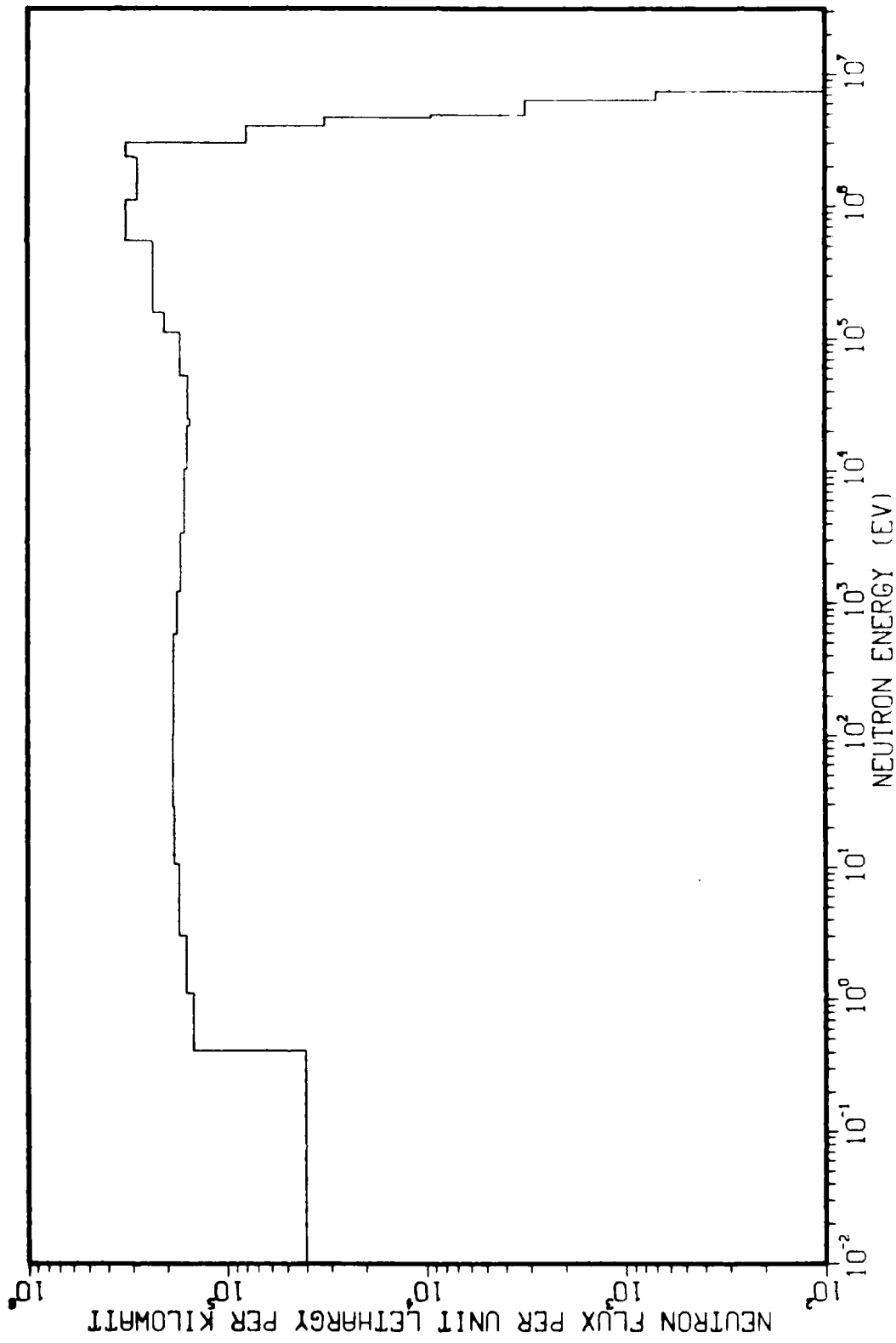

Figure II.6.15. Back Neutron Flux vs Energy Free Field ERI 100 CMS from Reactor.

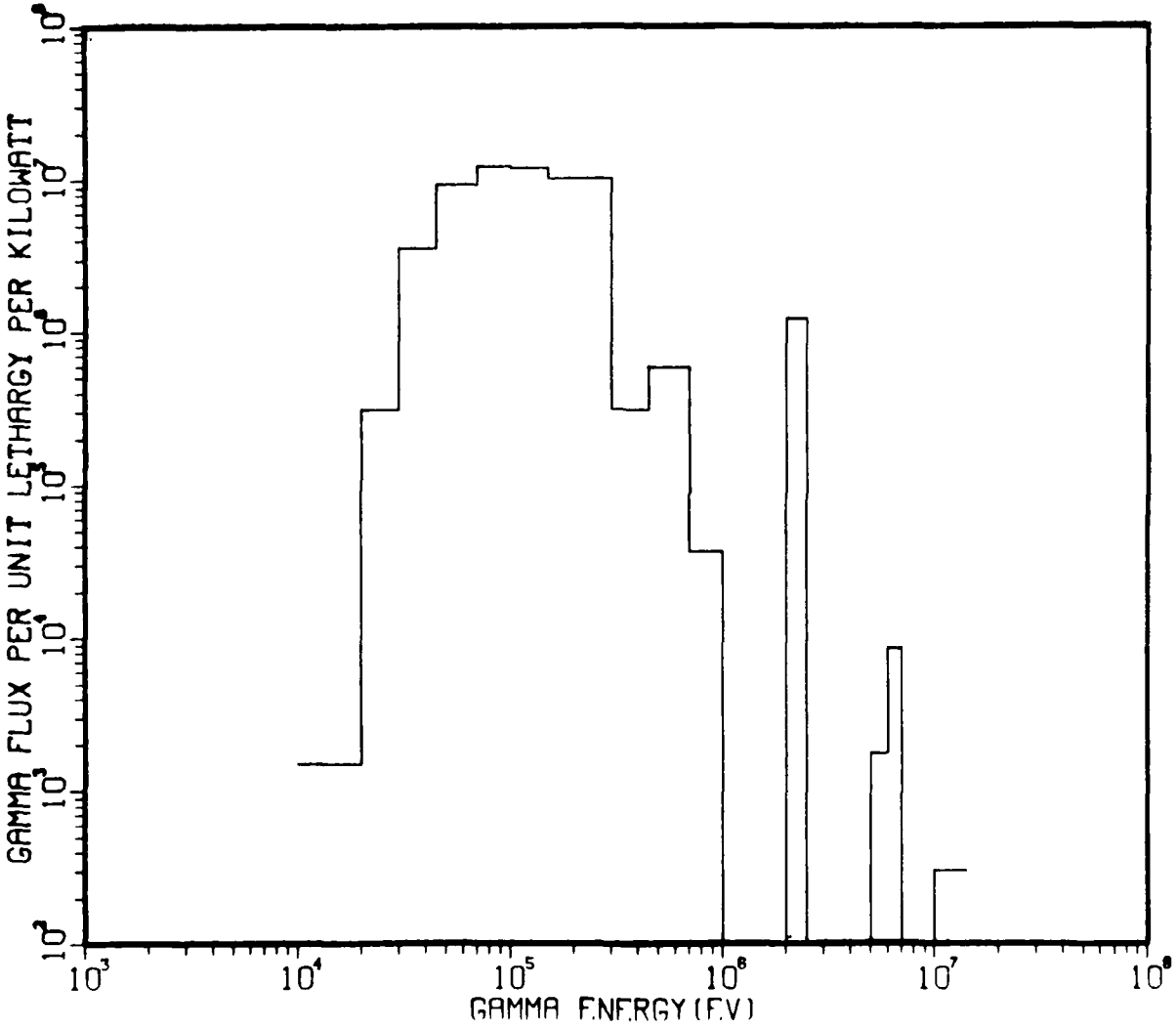

Figure II.6.16. Back Gamma Flux vs Energy Free Field ER1 100 CMS from Reactor.

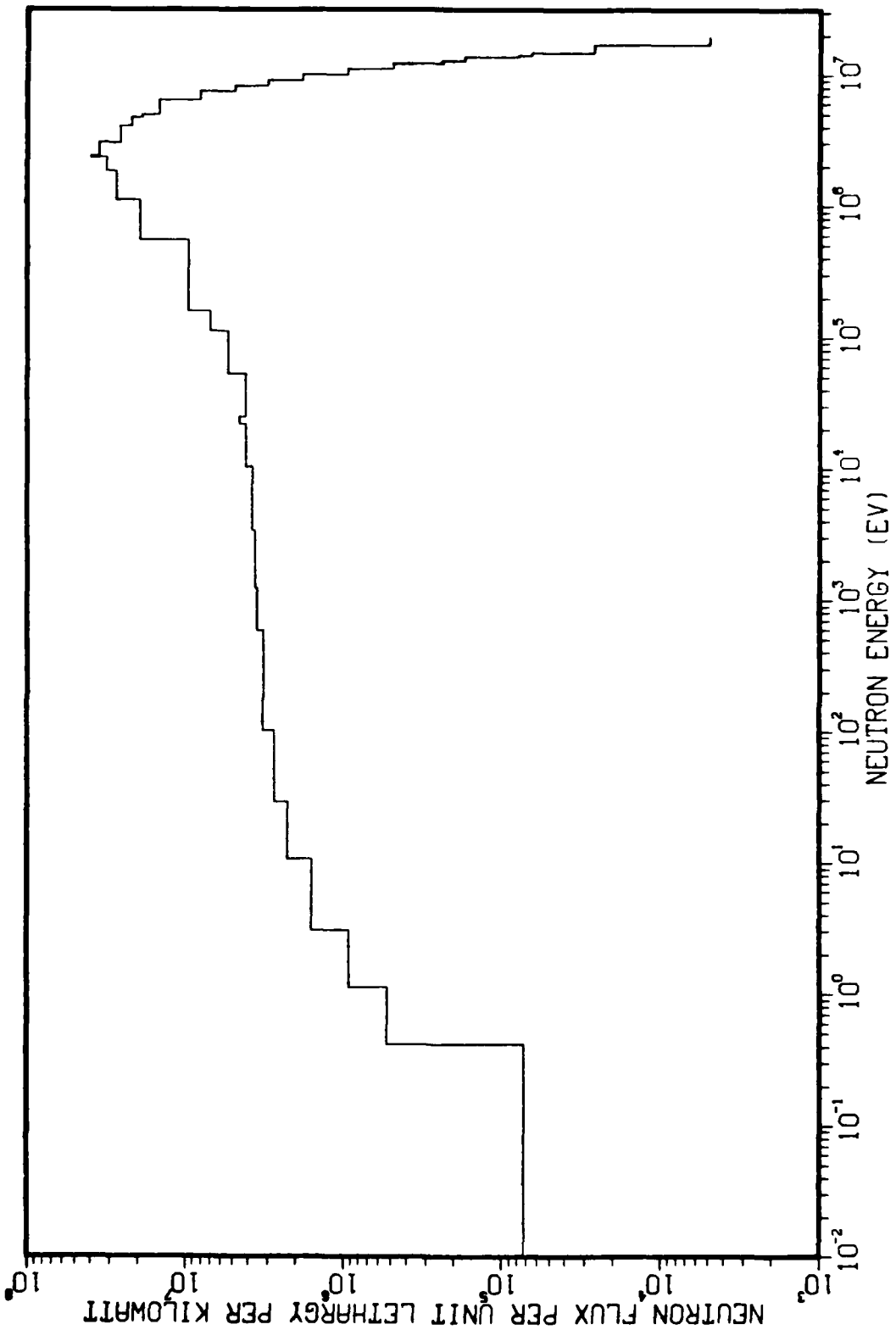

Figure II.6.17. Total Neutron Flux vs Energy Free Field ER1 100 CMS from Reactor.

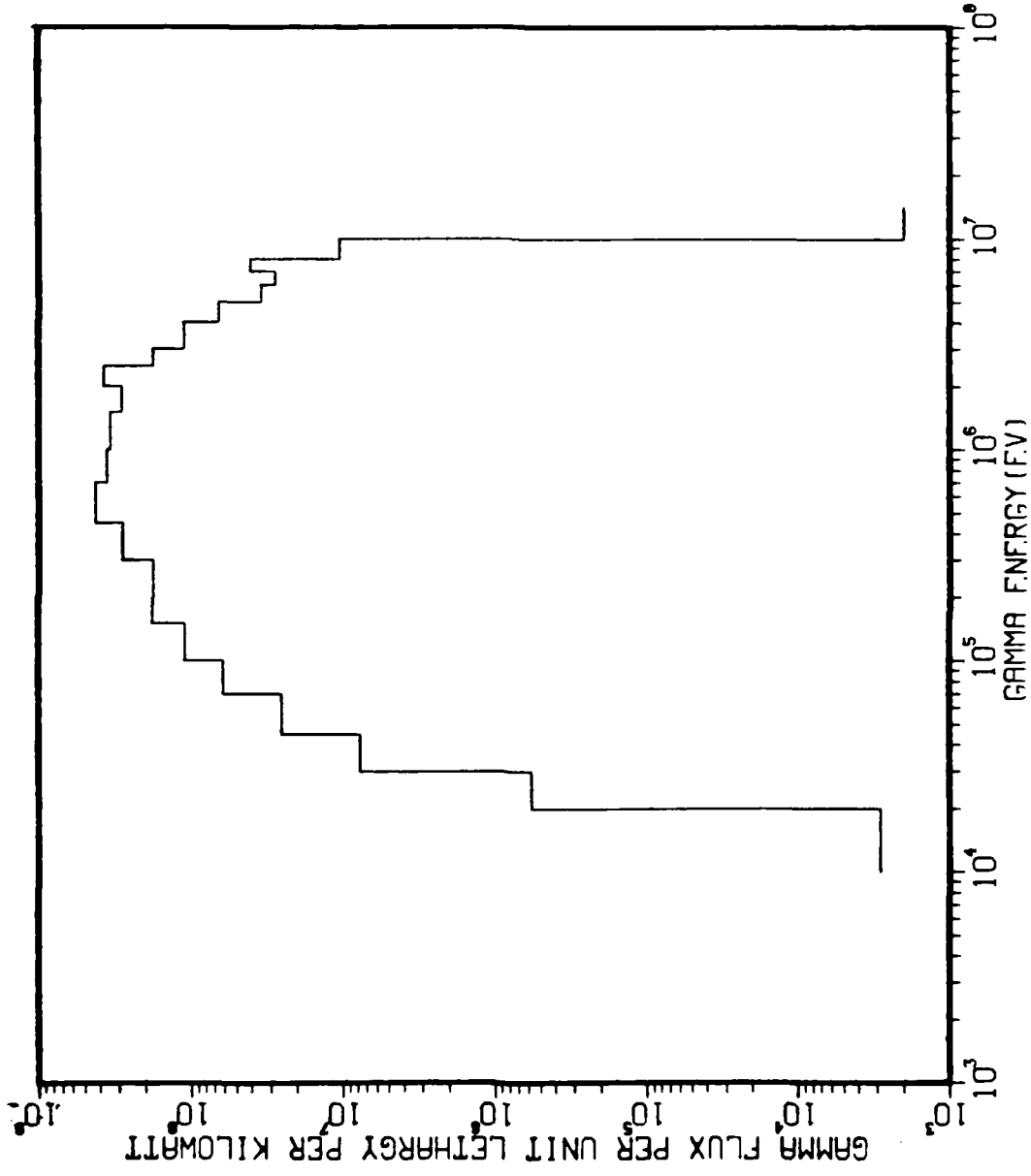

Figure II.6.18. Total Gamma Flux vs Energy Free Field ER1 100 CMS from Reactor.

Table II.6.3. Neutron Flux per Unit Lethargy per Kilowatt.

ER1 FREE FIELD 100 CMS FROM REACTOR

GROUP	ENERGY (EV)	FRONT	BACK	TOTAL
1	1.960E+07	4.97E+03	0.00E+00	4.97E+03
2	1.690E+07	2.66E+04	0.00E+00	2.66E+04
3	1.490E+07	6.56E+04	0.00E+00	6.56E+04
4	1.420E+07	7.91E+04	0.00E+00	7.91E+04
5	1.380E+07	1.74E+05	0.00E+00	1.74E+05
6	1.280E+07	2.41E+05	0.00E+00	2.41E+05
7	1.220E+07	4.93E+05	0.00E+00	4.93E+05
8	1.110E+07	9.53E+05	0.00E+00	9.53E+05
9	1.000E+07	1.86E+06	0.00E+00	1.86E+06
10	9.050E+06	3.97E+06	0.00E+00	3.07E+06
11	8.190E+06	4.91E+06	0.00E+00	4.91E+06
12	7.410E+06	8.13E+06	7.06E+02	8.13E+06
13	6.380E+06	1.48E+07	3.20E+03	1.48E+07
14	4.970E+06	1.89E+07	9.47E+03	1.89E+07
15	4.720E+06	2.22E+07	3.23E+04	2.22E+07
16	4.070E+06	2.61E+07	8.05E+04	2.62E+07
17	3.010E+06	3.52E+07	3.21E+05	3.56E+07
18	2.390E+06	3.97E+07	2.98E+05	4.00E+07
19	2.310E+06	3.15E+07	2.83E+05	3.18E+07
20	1.830E+06	2.71E+07	2.82E+05	2.74E+07
21	1.110E+06	1.93E+07	3.23E+05	1.96E+07
22	5.500E+05	9.52E+06	2.35E+05	9.75E+06
23	1.580E+05	6.87E+06	2.06E+05	7.08E+06
24	1.110E+05	5.27E+06	1.72E+05	5.44E+06
25	5.250E+04	4.05E+06	1.57E+05	4.21E+06
26	2.480E+04	4.48E+06	1.54E+05	4.63E+06
27	2.190E+04	4.05E+06	1.58E+05	4.20E+06
28	1.030E+04	3.69E+06	1.64E+05	3.85E+06
29	3.350E+03	3.50E+06	1.71E+05	3.67E+06
30	1.230E+03	3.38E+06	1.79E+05	3.56E+06
31	5.830E+02	3.09E+06	1.85E+05	3.27E+06
32	1.010E+02	2.58E+06	1.87E+05	2.77E+06
33	2.900E+01	2.09E+06	1.85E+05	2.27E+06
34	1.070E+01	1.44E+06	1.74E+05	1.61E+06
35	3.060E+00	7.69E+05	1.60E+05	9.29E+05
36	1.130E+00	3.82E+05	1.48E+05	5.30E+05
37	4.140E-01	3.24E+04	4.05E+04	7.29E+04

Table II.6.4. Gamma Flux per Unit Lethargy per Kilowatt.

ERI FREE FIELD 100 CMS FROM REACTOR

GROUP	ENERGY (EV)	FRONT	BACK	TOTAL
1	1.400E+07	1.68E+03	3.01E+02	1.98E+03
2	1.000E+07	1.05E+07	0.00E+00	1.05E+07
3	8.000E+06	4.07E+07	0.00E+00	4.07E+07
4	7.000E+06	2.81E+07	8.57E+03	2.81E+07
5	6.000E+06	3.48E+07	1.75E+03	3.48E+07
6	5.000E+06	6.61E+07	0.09E+00	6.61E+07
7	4.000E+06	1.11E+08	0.00E+00	1.11E+08
8	3.000E+06	1.77E+08	0.00E+00	1.77E+08
9	2.500E+06	3.73E+08	1.22E+06	3.74E+08
10	2.000E+06	2.85E+08	0.00E+00	2.85E+08
11	1.500E+06	3.41E+08	0.00E+00	3.41E+08
12	1.000E+06	3.58E+08	3.67E+04	3.58E+08
13	7.000E+05	4.24E+08	5.95E+05	4.25E+08
14	4.500E+05	2.84E+08	3.12E+05	2.84E+08
15	3.000E+05	1.69E+08	1.02E+07	1.79E+08
16	1.500E+05	9.78E+07	1.19E+07	1.10E+08
17	1.000E+05	4.93E+07	1.21E+07	6.14E+07
18	7.000E+04	1.60E+07	9.24E+06	2.52E+07
19	4.500E+04	4.22E+06	3.54E+06	7.76E+06
20	3.000E+04	2.68E+05	3.12E+05	5.79E+05
21	2.000E+04	1.38E+03	1.49E+03	2.87E+03

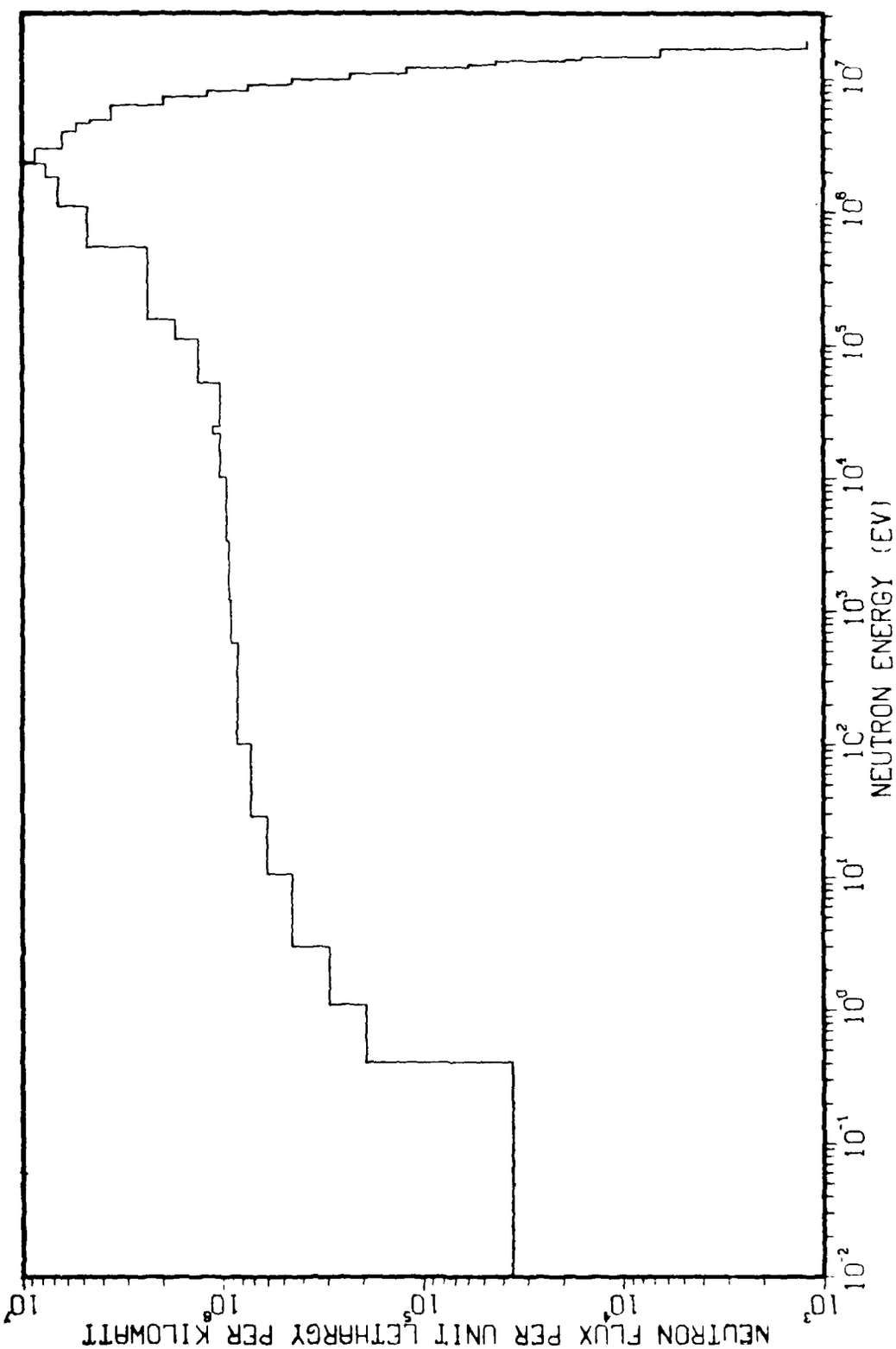

Figure II.6.19. Front Neutron Flux vs Energy Free Field ERI 200 CMS from Reactor.

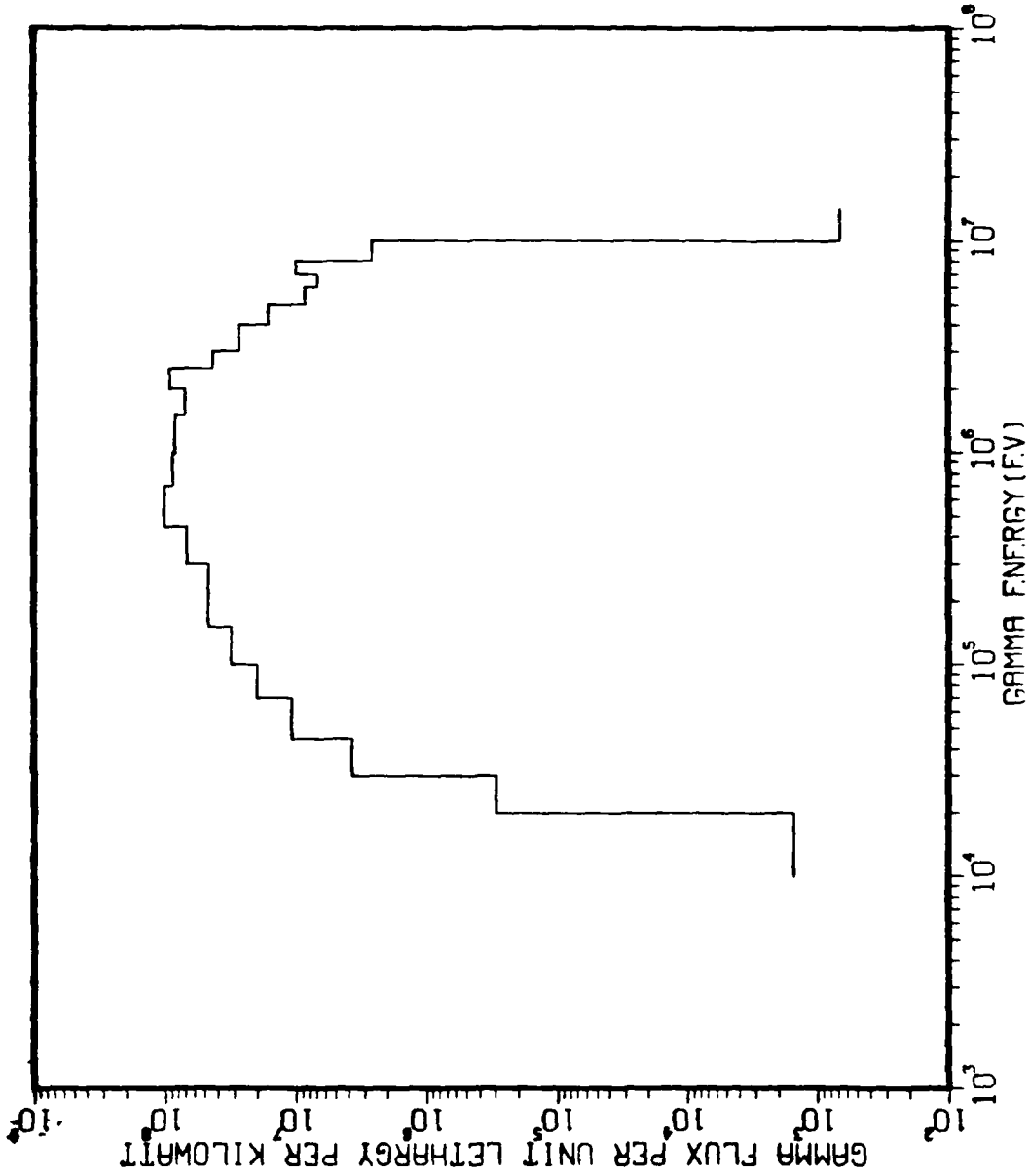

Figure II.6.20. Front Gamma Flux vs Energy Free Field ERI 200 CMS from Reactor.

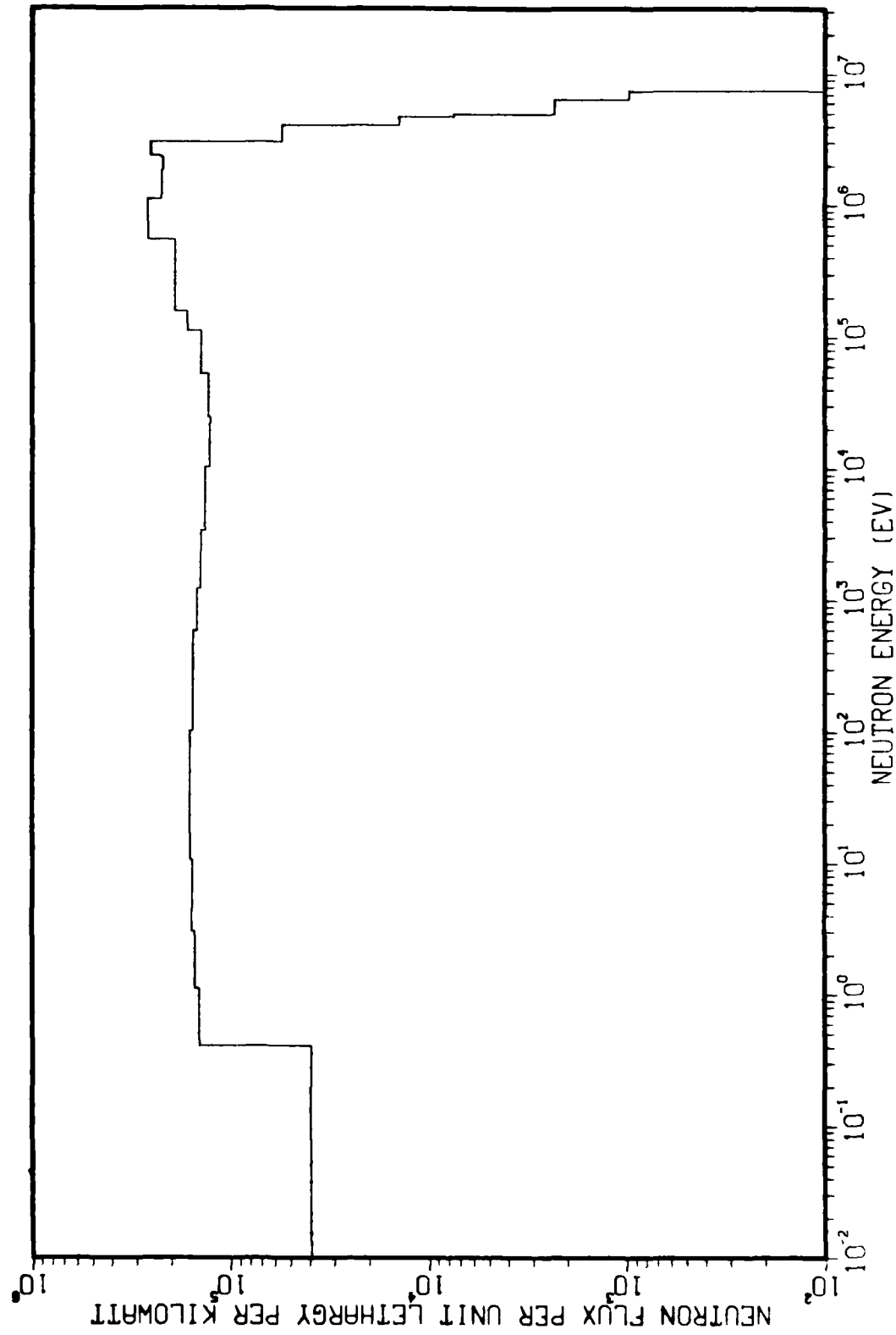

Figure II.6.21. Back Neutron Flux vs Energy Free Field ERI 200 CMS from Reactor.

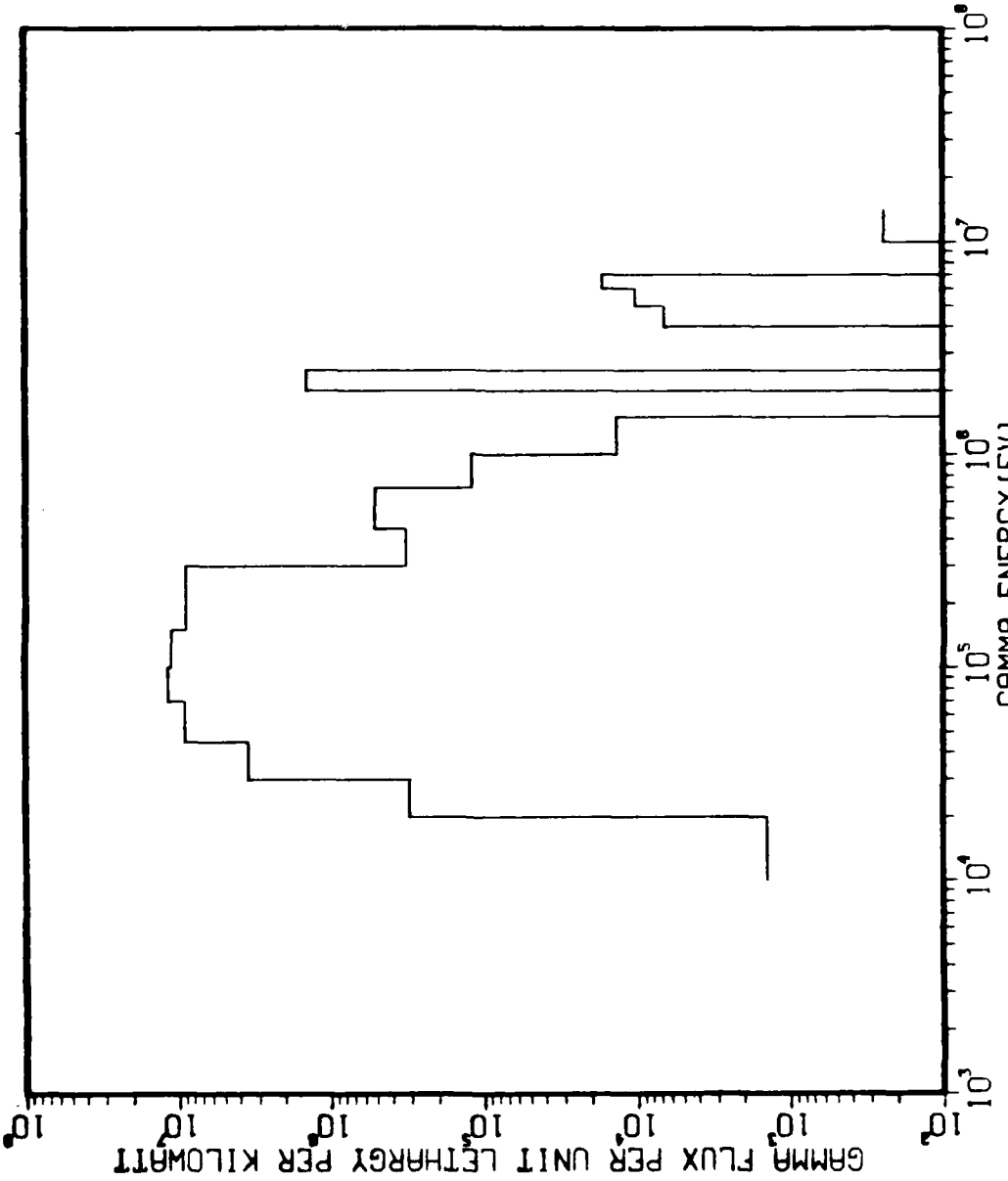

Figure II.6.22. Back Gamma Flux vs Energy Free Field ER1 200 CMS from Reactor.

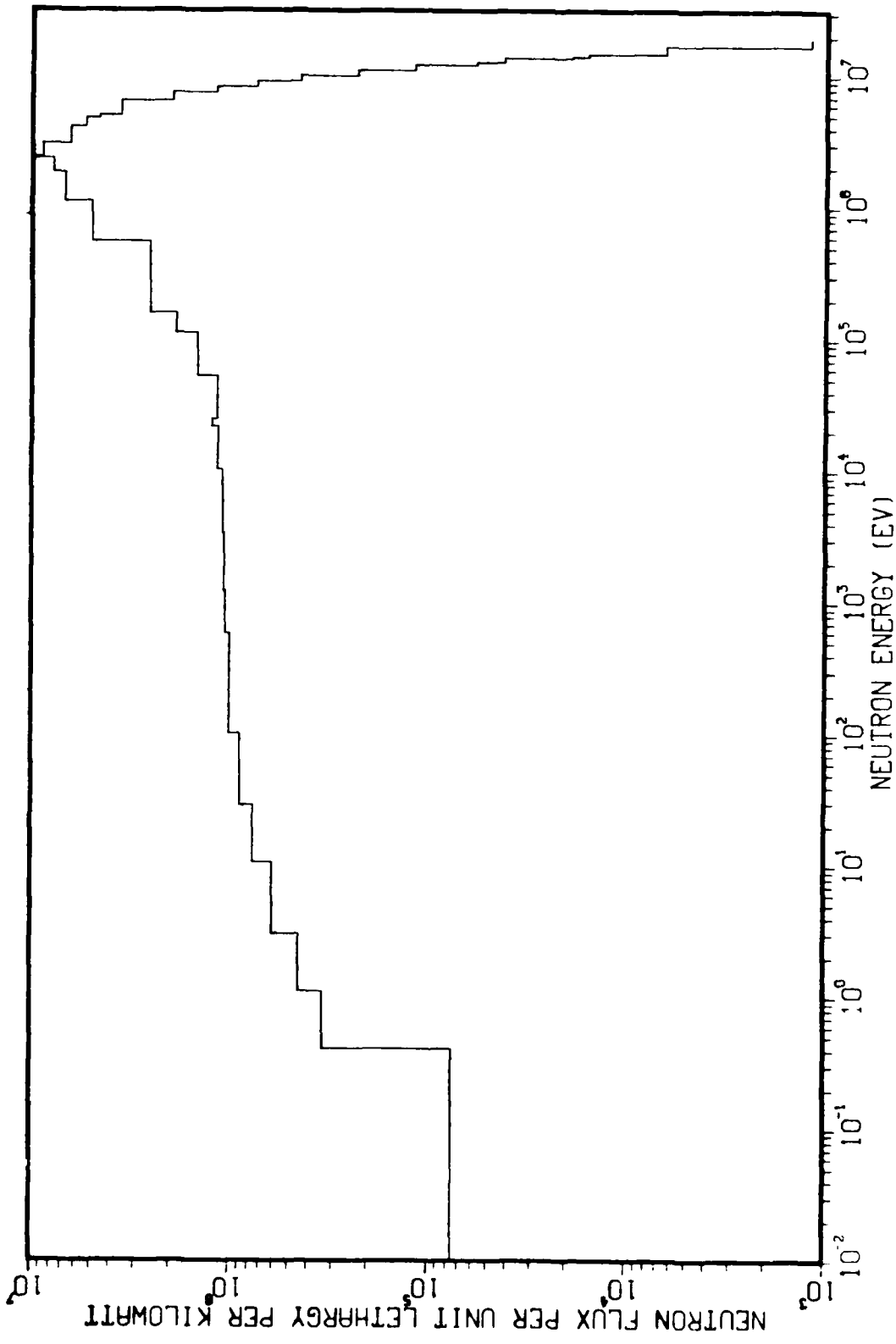

Figure II.6.23. Total Neutron Flux vs Energy Free Field ERI 200 CMS from Reactor.

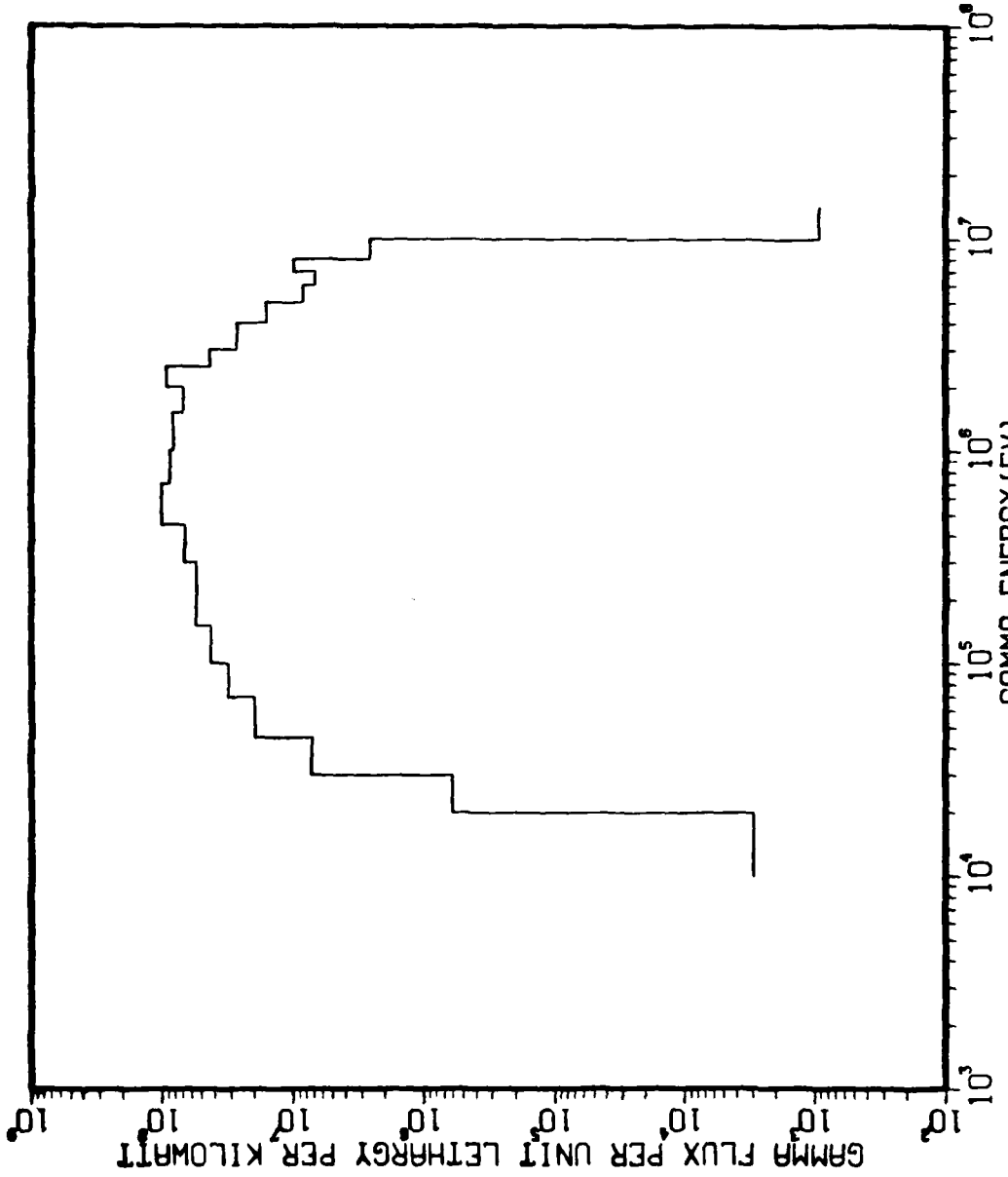

Figure II.6.24. Total Gamma Flux vs Energy Free Field ER1 200 CMS from Reactor.

Table II.6.5. Neutron Flux per Unit Lethargy per Kilowatt.

ERI FREE FIELD 200 CMS FROM REACTOR

GROUP	ENERGY (EV)	FRONT	BACK	TOTAL
1	1.960E+07	1.21E+03	0.00E+00	1.21E+03
2	1.690E+07	6.46E+03	0.00E+00	6.46E+03
3	1.490E+07	1.59E+04	0.00E+00	1.59E+04
4	1.420E+07	1.92E+04	0.00E+00	1.92E+04
5	1.380E+07	4.22E+04	0.00E+00	4.22E+04
6	1.280E+07	5.84E+04	0.00E+00	5.84E+04
7	1.220E+07	1.20E+05	0.00E+00	1.20E+05
8	1.110E+07	2.32E+05	0.00E+00	2.32E+05
9	1.000E+07	4.51E+05	0.00E+00	4.51E+05
10	9.050E+06	7.46E+05	0.00E+00	7.46E+05
11	8.190E+06	1.19E+06	0.00E+00	1.19E+06
12	7.410E+06	1.97E+06	9.80E+02	1.98E+06
13	6.380E+06	3.59E+06	2.31E+03	3.60E+06
14	4.970E+06	4.59E+06	7.54E+03	4.60E+06
15	4.720E+06	5.37E+06	1.42E+04	5.38E+06
16	4.070E+06	6.31E+06	5.52E+04	6.36E+06
17	3.010E+06	8.63E+06	2.54E+05	8.88E+06
18	2.390E+06	9.68E+06	2.24E+05	9.90E+06
19	2.310E+06	7.66E+06	2.18E+05	7.88E+06
20	1.830E+06	6.58E+06	2.22E+05	6.80E+06
21	1.110E+06	4.72E+06	2.61E+05	4.98E+06
22	5.500E+05	2.36E+06	1.91E+05	2.55E+06
23	1.580E+05	1.72E+06	1.65E+05	1.88E+06
24	1.110E+05	1.33E+06	1.41E+05	1.47E+06
25	5.250E+04	1.04E+06	1.29E+05	1.17E+06
26	2.480E+04	1.12E+06	1.26E+05	1.25E+06
27	2.190E+04	1.04E+06	1.28E+05	1.16E+06
28	1.030E+04	9.58E+05	1.34E+05	1.09E+06
29	3.350E+03	9.38E+05	1.41E+05	1.08E+06
30	1.230E+03	9.13E+05	1.48E+05	1.06E+06
31	5.830E+02	8.51E+05	1.55E+05	1.01E+06
32	1.010E+02	7.28E+05	1.60E+05	8.88E+05
33	2.900E+01	6.05E+05	1.60E+05	7.65E+05
34	1.070E+01	4.55E+05	1.56E+05	6.11E+05
35	3.060E+00	2.96E+05	1.51E+05	4.47E+05
36	1.130E+00	1.94E+05	1.44E+05	3.38E+05
37	4.140E-01	3.58E+04	3.94E+04	7.52E+04

Table II.6.6. Gamma Flux per Unit Lethargy per Kilowatt.

ER1 FREE FIELD 200 CMS FROM REACTOR

GROUP	ENERGY (EV)	FRONT	BACK	TOTAL
1	1.400E+07	6.70E+02	2.44E+02	9.14E+02
2	1.000E+07	2.57E+06	0.00E+00	2.57E+06
3	8.000E+06	9.86E+06	0.00E+00	9.86E+06
4	7.000E+06	6.78E+06	1.69E+04	6.79E+06
5	6.000E+06	8.40E+06	1.03E+04	8.41E+06
6	5.000E+06	1.60E+07	6.70E+03	1.60E+07
7	4.000E+06	2.70E+07	0.00E+00	2.70E+07
8	3.000E+06	4.31E+07	0.00E+00	4.31E+07
9	2.500E+06	9.08E+07	1.41E+06	9.22E+07
10	2.000E+06	6.93E+07	0.00E+00	6.93E+07
11	1.500E+06	8.26E+07	1.36E+04	8.26E+07
12	1.000E+06	8.64E+07	1.20E+05	8.65E+07
13	7.000E+05	1.00E+08	5.19E+05	1.01E+08
14	4.500E+05	6.71E+07	3.22E+05	6.74E+07
15	3.000E+05	4.61E+07	8.94E+06	5.51E+07
16	1.500E+05	3.15E+07	1.11E+07	4.26E+07
17	1.000E+05	1.97E+07	1.16E+07	3.13E+07
18	7.000E+04	1.08E+07	9.07E+06	1.99E+07
19	4.500E+04	3.69E+06	3.52E+06	7.21E+06
20	3.000E+04	2.92E+05	3.08E+05	6.01E+05
21	2.000E+04	1.52E+03	1.42E+03	2.94E+03

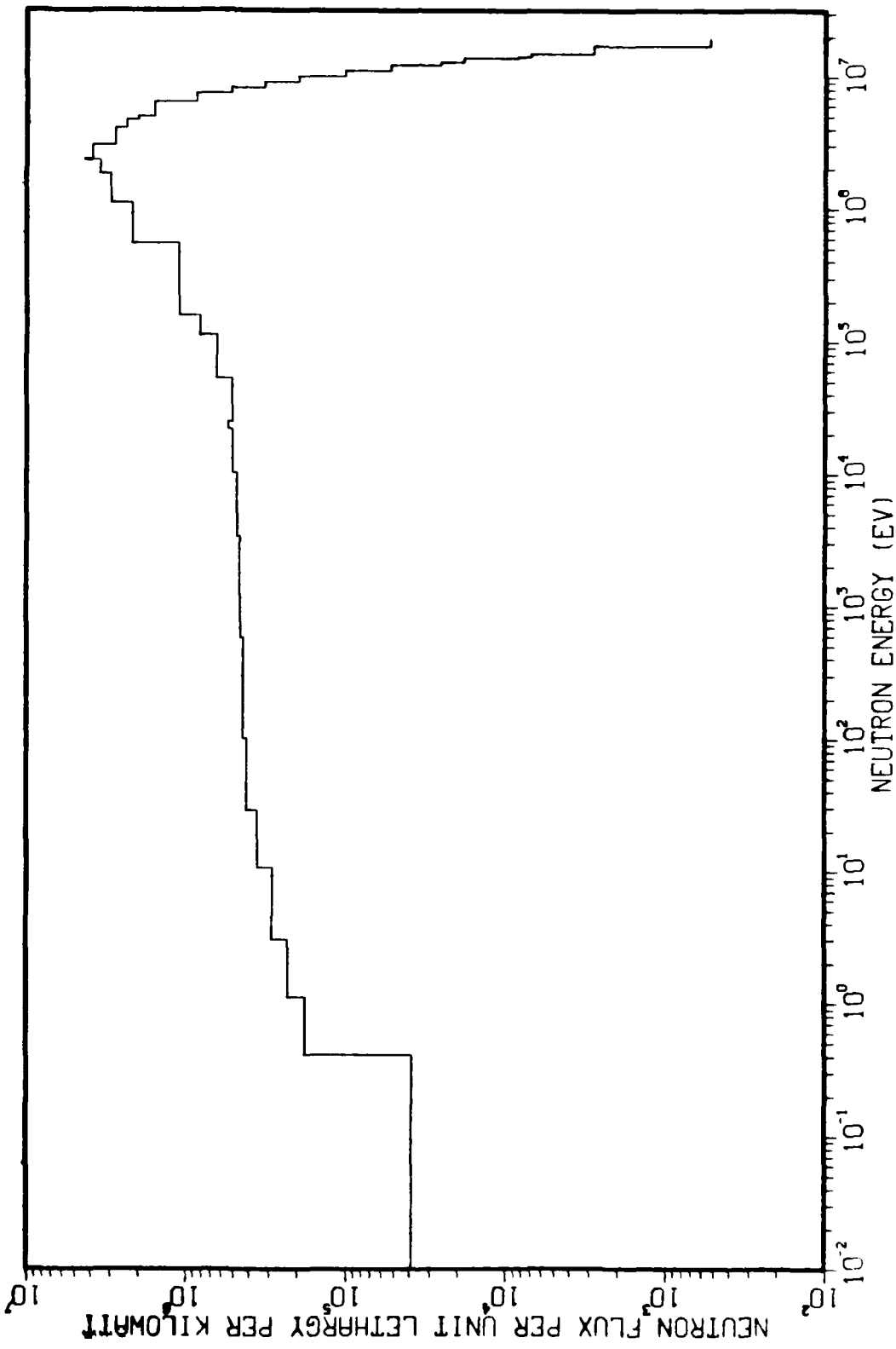

Figure II.6.25. Front Neutron Flux vs Energy Free Field ERI 300 CMS from Reactor.

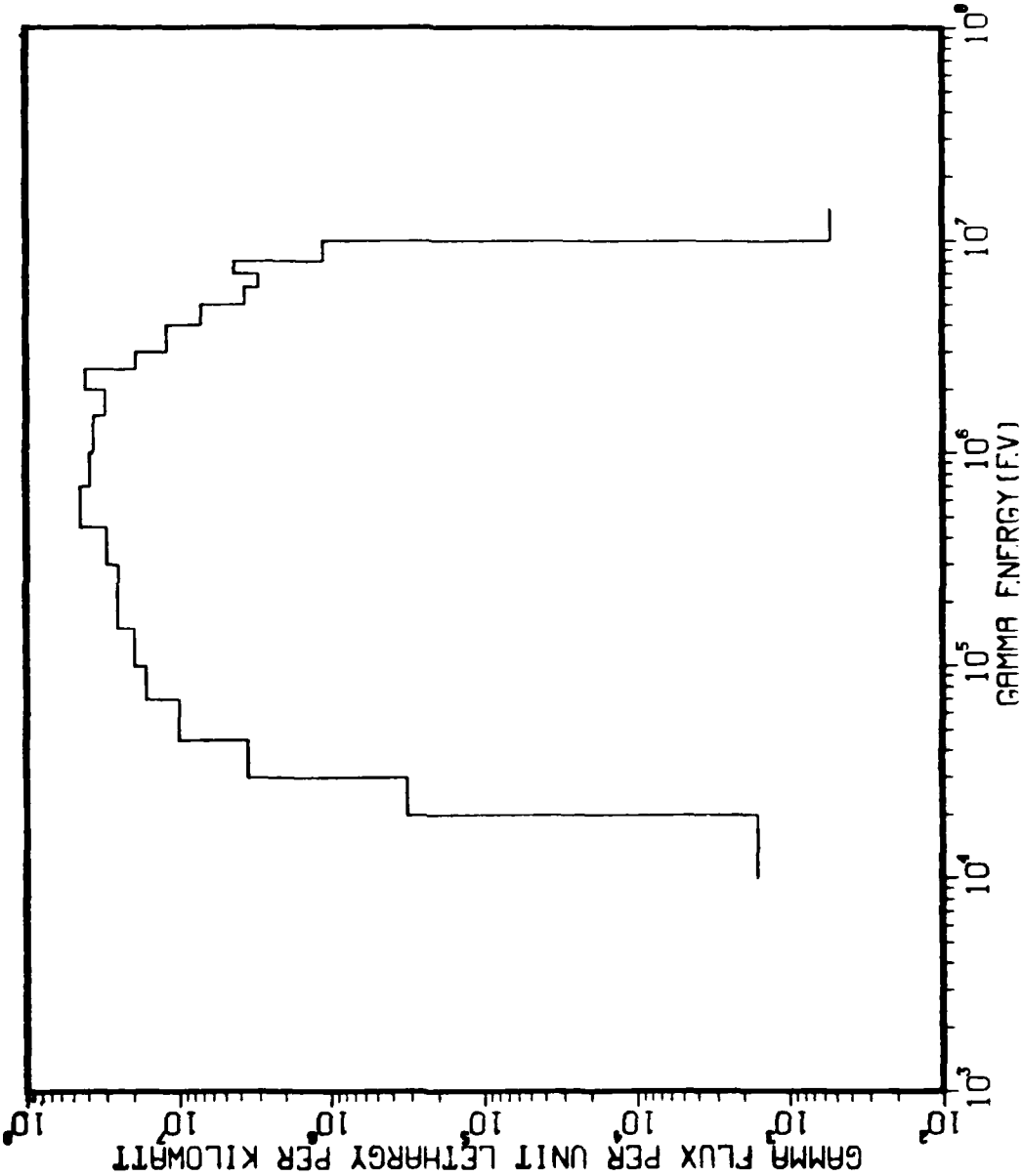

Figure II.6.26. Front Gamma Flux vs Energy Free Field ER1 300 CMS from Reactor.

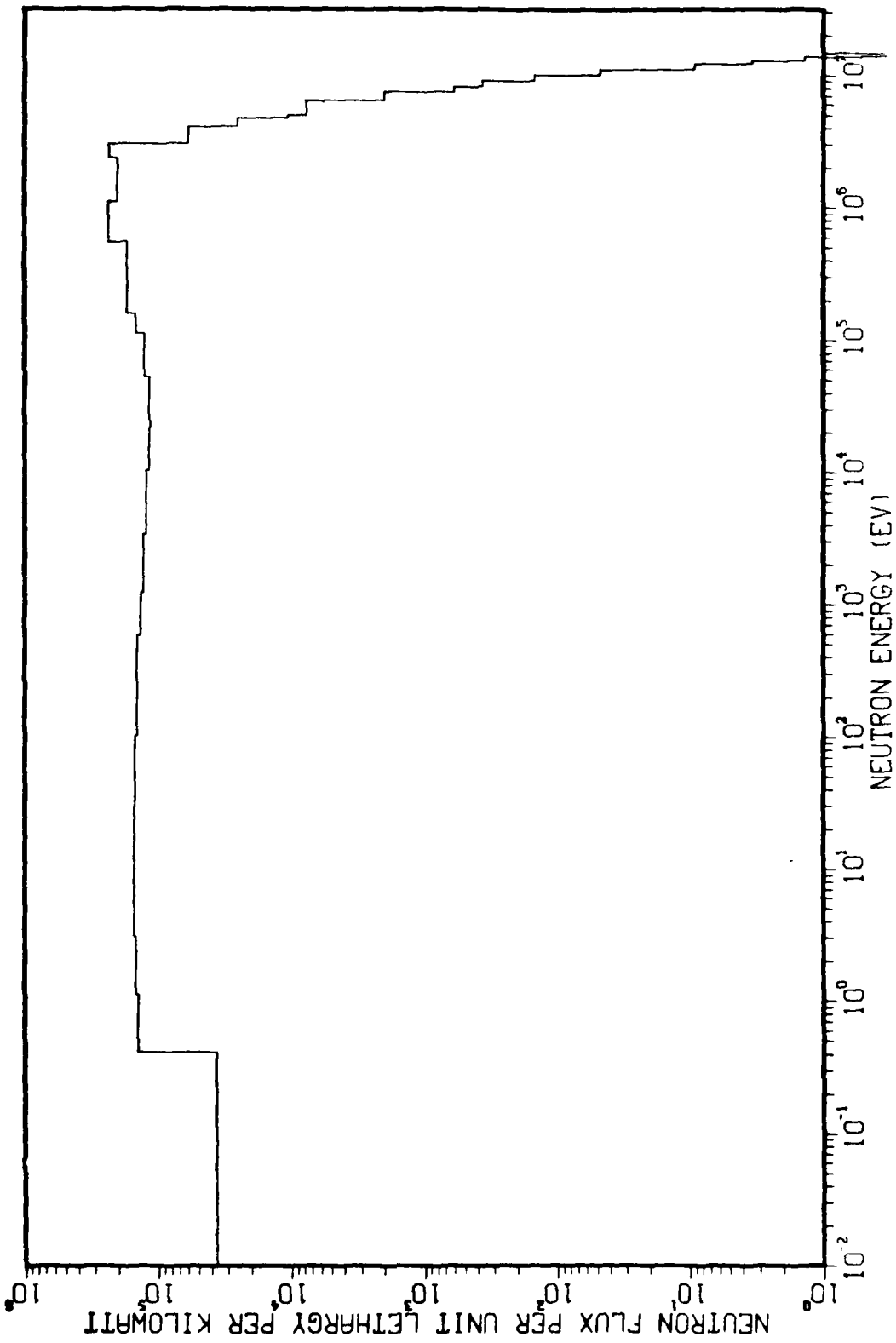

Figure II.6.27. Back Neutron Flux vs Energy Free Field ER1 300 CMS from Reactor.

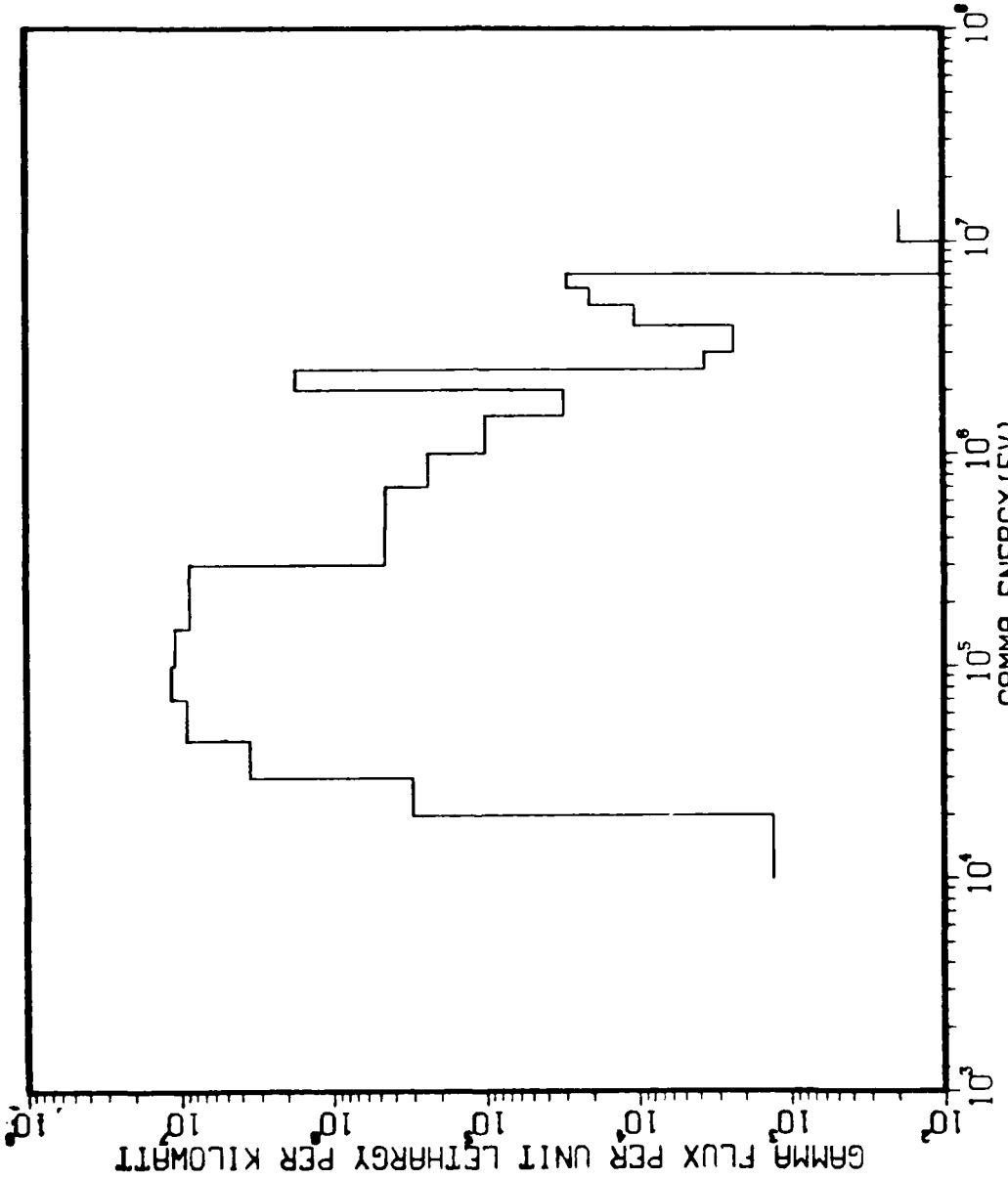

Figure II.6.28. Back Gamma Flux vs Energy Free Field ER1 300 CMS from Reactor.

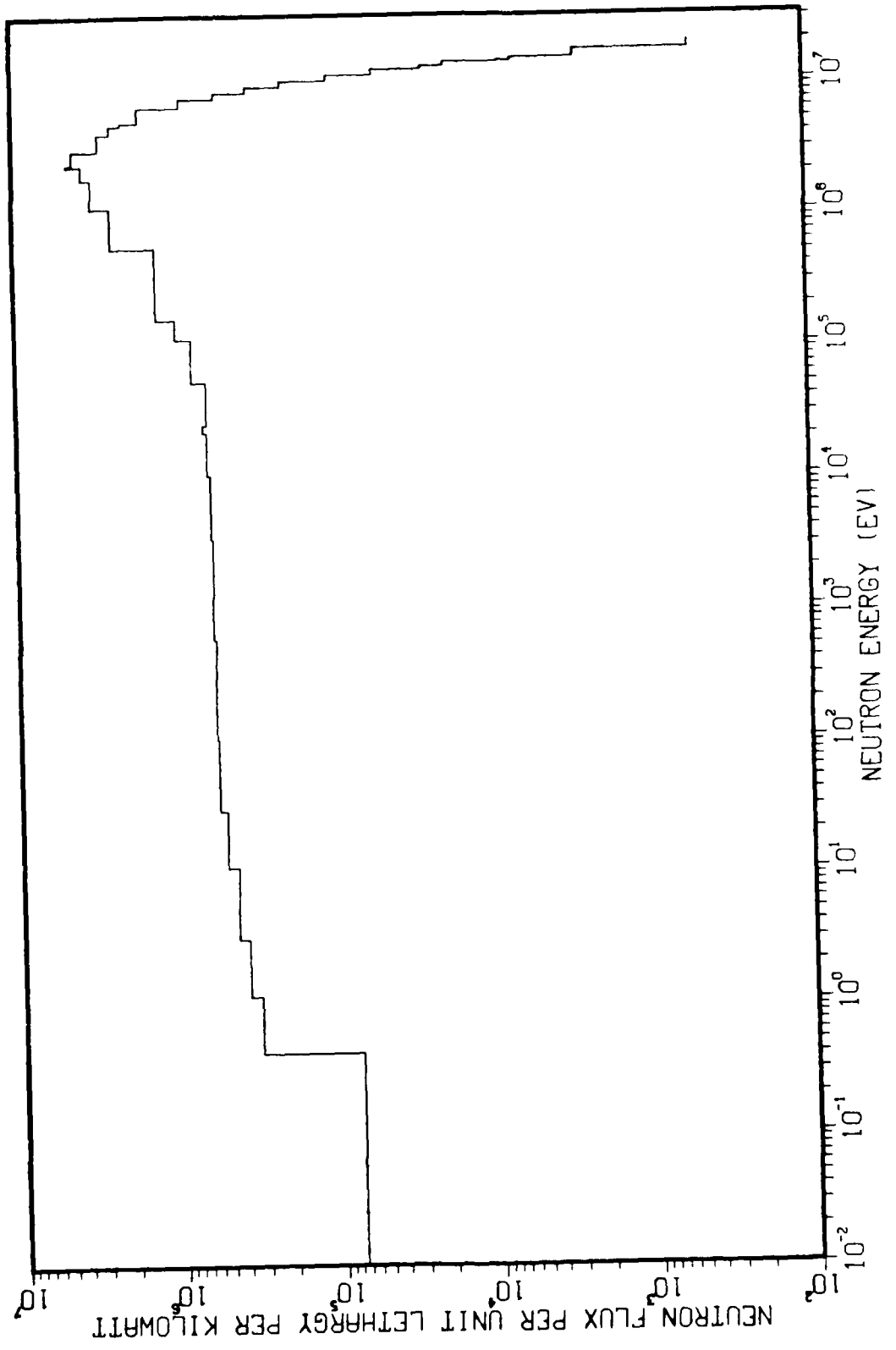

Figure II.6.29. Total Neutron Flux vs Energy Free Field ERI 300 CMS from Reactor.

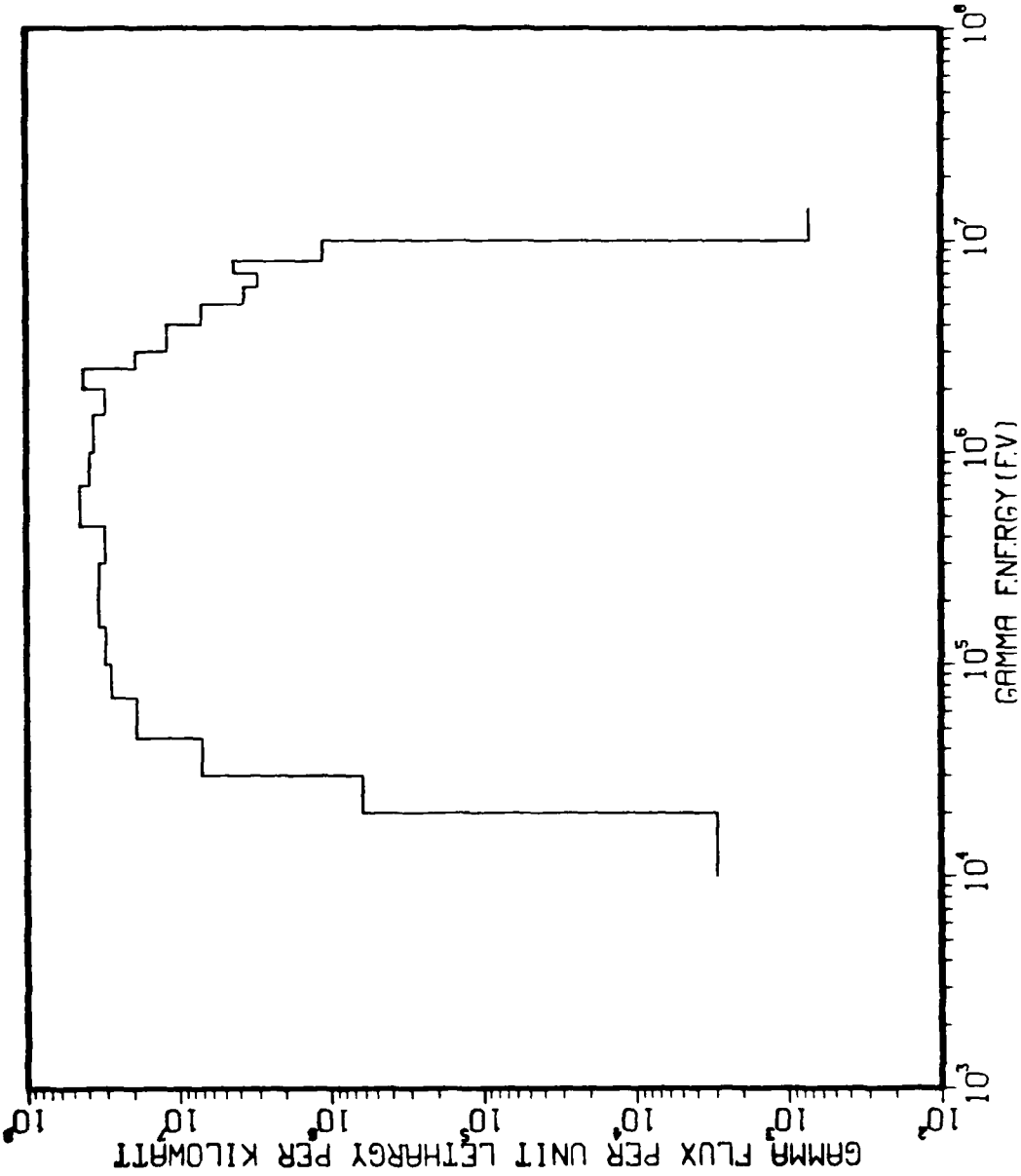

Figure II.6.30. Total Gamma Flux vs Energy Free Field ER1 300 CMS from Reactor.

Table II.6.7. Neutron Flux per Unit Lethargy per Kilowatt.

ERI FREE FIELD 300 CMS FROM REACTOR

GROUP	ENERGY (EV)	FRONT	BACK	TOTAL
1	1.960E+07	5.29E+02	0.00E+00	5.29E+02
2	1.690E+07	2.83E+03	0.00E+00	2.83E+03
3	1.490E+07	6.98E+03	1.85E-01	6.98E+03
4	1.420E+07	8.42E+03	5.14E-01	8.42E+03
5	1.380E+07	1.85E+04	1.38E+00	1.85E+04
6	1.280E+07	2.56E+04	3.41E+00	2.56E+04
7	1.220E+07	5.25E+04	9.26E+00	5.25E+04
8	1.110E+07	1.02E+05	4.72E+01	1.02E+05
9	1.000E+07	1.98E+05	1.47E+02	1.98E+05
10	9.050E+06	3.27E+05	3.63E+02	3.28E+05
11	8.190E+06	5.22E+05	5.96E+02	5.23E+05
12	7.410E+06	8.69E+05	1.99E+03	8.70E+05
13	6.380E+06	1.58E+06	7.77E+03	1.59E+06
14	4.970E+06	2.03E+06	1.07E+04	2.04E+06
15	4.720E+06	2.38E+06	2.56E+04	2.40E+06
16	4.070E+06	2.81E+06	5.94E+04	2.87E+06
17	3.010E+06	3.90E+06	2.35E+05	4.14E+06
18	2.390E+06	4.35E+06	2.04E+05	4.56E+06
19	2.310E+06	3.47E+06	2.02E+05	3.67E+06
20	1.830E+06	3.00E+06	2.04E+05	3.20E+06
21	1.110E+06	2.19E+06	2.36E+05	2.43E+06
22	5.500E+05	1.11E+06	1.72E+05	1.29E+06
23	1.580E+05	8.24E+05	1.49E+05	9.73E+05
24	1.110E+05	6.44E+05	1.28E+05	7.72E+05
25	5.250E+04	5.11E+05	1.18E+05	6.29E+05
26	2.480E+04	5.47E+05	1.16E+05	6.63E+05
27	2.190E+04	5.12E+05	1.17E+05	6.29E+05
28	1.030E+04	4.81E+05	1.23E+05	6.04E+05
29	3.350E+03	4.65E+05	1.30E+05	5.95E+05
30	1.230E+03	4.60E+05	1.36E+05	5.96E+05
31	5.830E+02	4.39E+05	1.44E+05	5.83E+05
32	1.010E+02	4.15E+05	1.50E+05	5.66E+05
33	2.900E+01	3.59E+05	1.53E+05	5.12E+05
34	1.070E+01	2.90E+05	1.51E+05	4.41E+05
35	3.060E+00	2.30E+05	1.49E+05	3.79E+05
36	1.130E+00	1.80E+05	1.44E+05	3.23E+05
37	4.140E-01	3.85E+04	3.68E+04	7.53E+04

Table II.6.8. Gamma Flux per Unit Lethargy per Kilowatt.

ER1 FREE FIELD 300 CMS FROM REACTOR

GROUP	ENERGY (EV)	FRONT	BACK	TOTAL
1	1.400E+07	8.40E+02	1.93E+02	7.33E+02
2	1.000E+07	1.13E+06	0.00E+00	1.13E+06
3	8.000E+06	4.33E+06	0.00E+00	4.33E+06
4	7.000E+06	2.99E+06	2.90E+04	3.02E+06
5	6.000E+06	3.70E+06	2.04E+04	3.72E+06
6	5.000E+06	7.05E+06	1.05E+04	7.06E+06
7	4.000E+06	1.19E+07	2.33E+03	1.19E+07
8	3.000E+06	1.89E+07	3.61E+03	1.89E+07
9	2.500E+06	4.09E+07	1.72E+06	4.26E+07
10	2.000E+06	3.04E+07	3.04E+04	3.04E+07
11	1.500E+06	3.62E+07	9.92E+04	3.63E+07
12	1.000E+06	3.80E+07	2.37E+05	3.83E+07
13	7.000E+05	4.42E+07	4.50E+05	4.47E+07
14	4.500E+05	2.98E+07	4.58E+05	3.03E+07
15	3.000E+05	2.48E+07	8.67E+06	3.35E+07
16	1.500E+05	1.95E+07	1.08E+07	3.04E+07
17	1.000E+05	1.63E+07	1.15E+07	2.78E+07
18	7.000E+04	1.00E+07	9.03E+06	1.90E+07
19	4.500E+04	3.54E+06	3.51E+06	7.05E+06
20	3.000E+04	3.20E+05	3.04E+05	6.24E+05
21	2.000E+04	1.63E+03	1.32E+03	2.95E+03

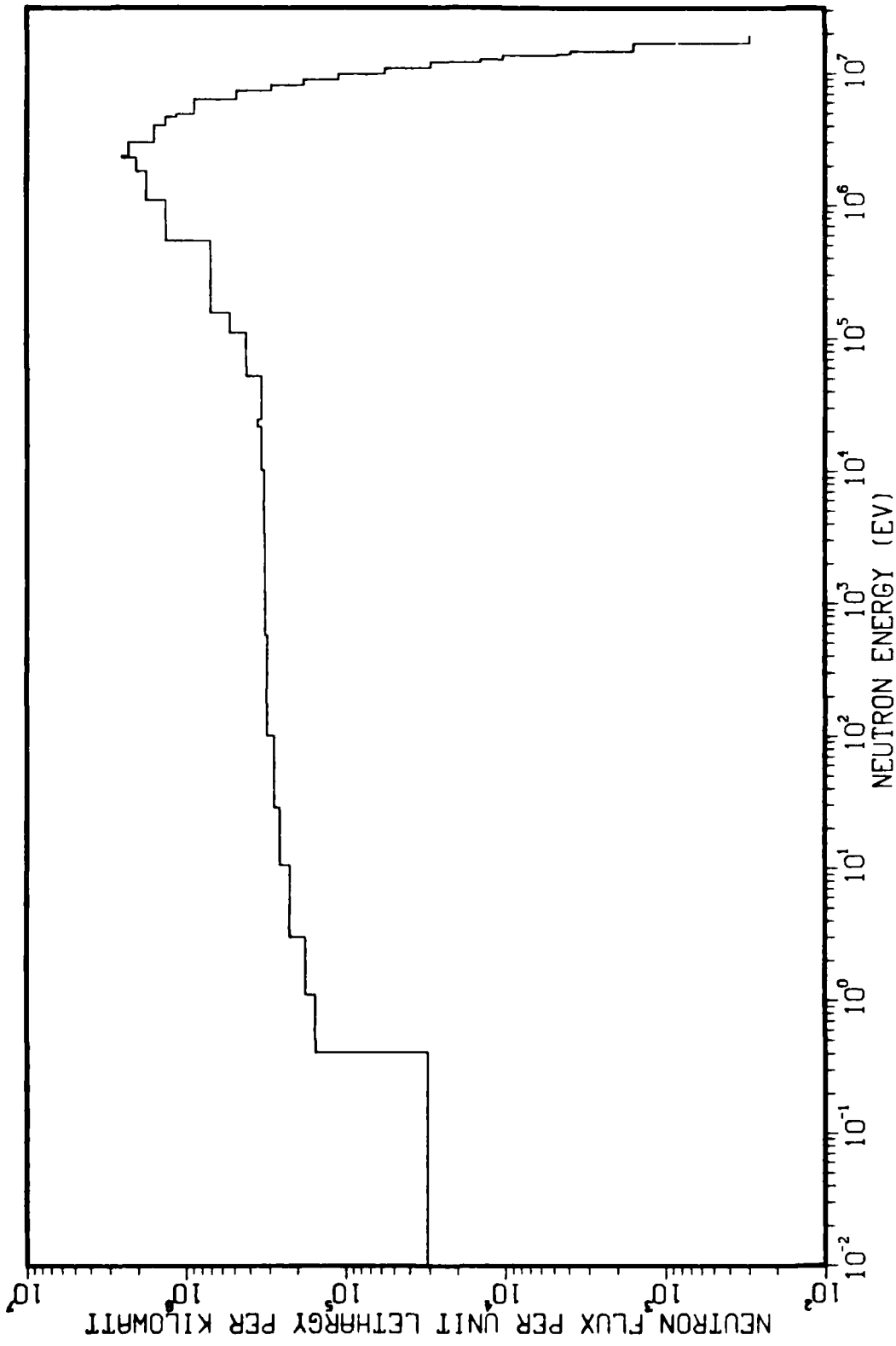

Figure II.6.31. Front Neutron Flux vs Energy Free Field ERI 400 CMS from Reactor.

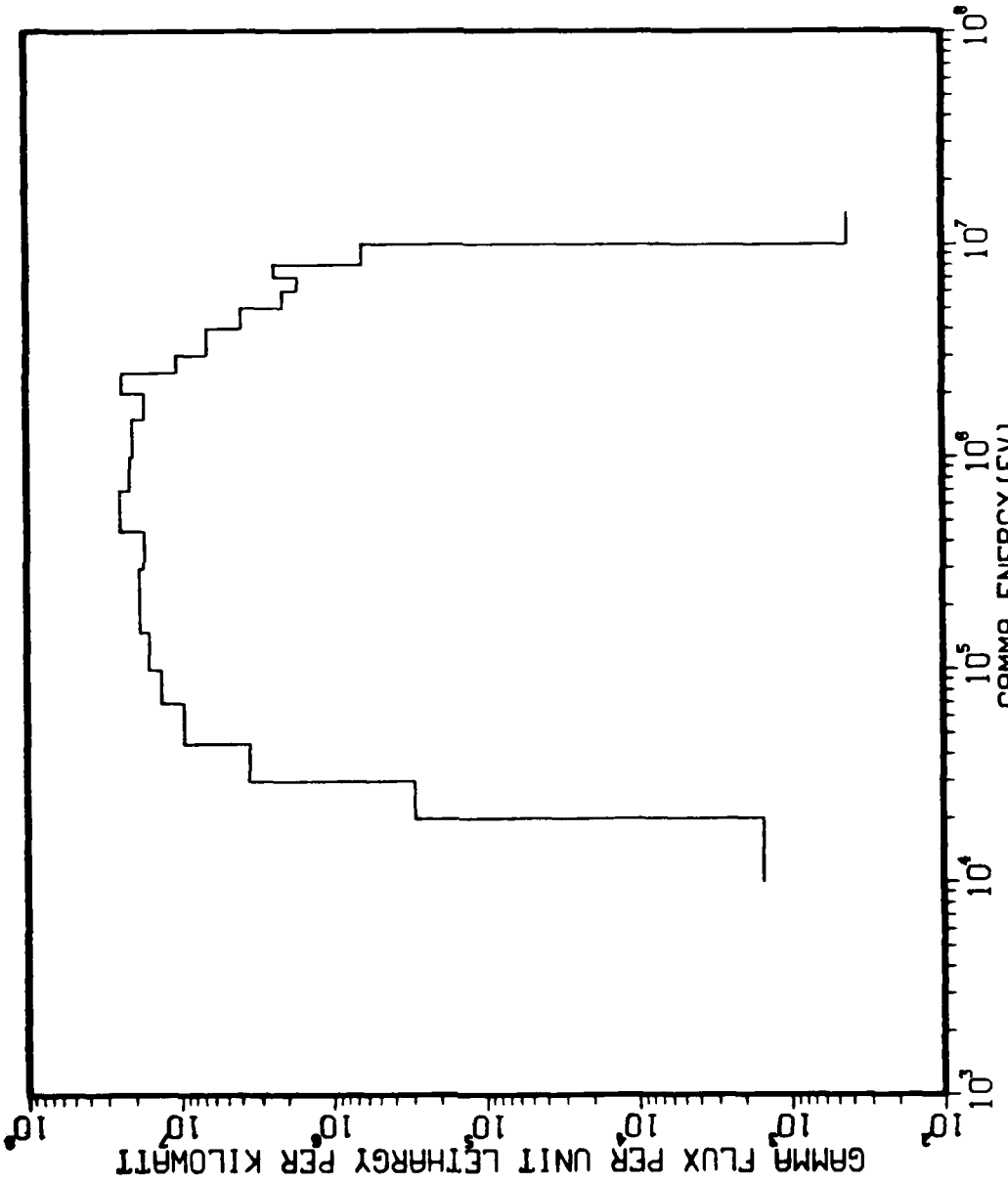

Figure II.6.32. Front Gamma Flux vs Energy Free Field ER1 400 CMS from Reactor.

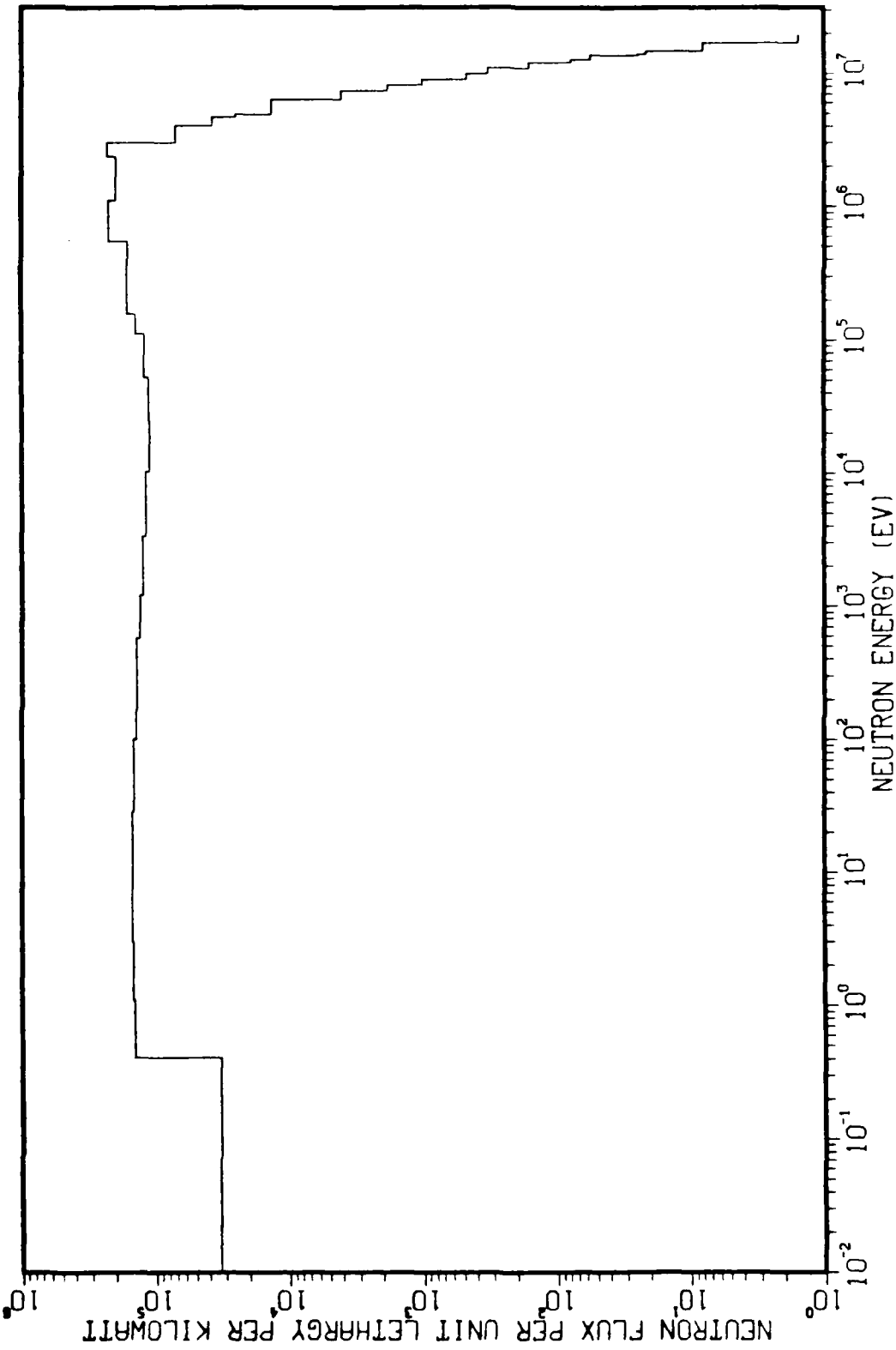

Figure II.6.33. Back Neutron Flux vs Energy Free Field ER1 400 CMS from Reactor.

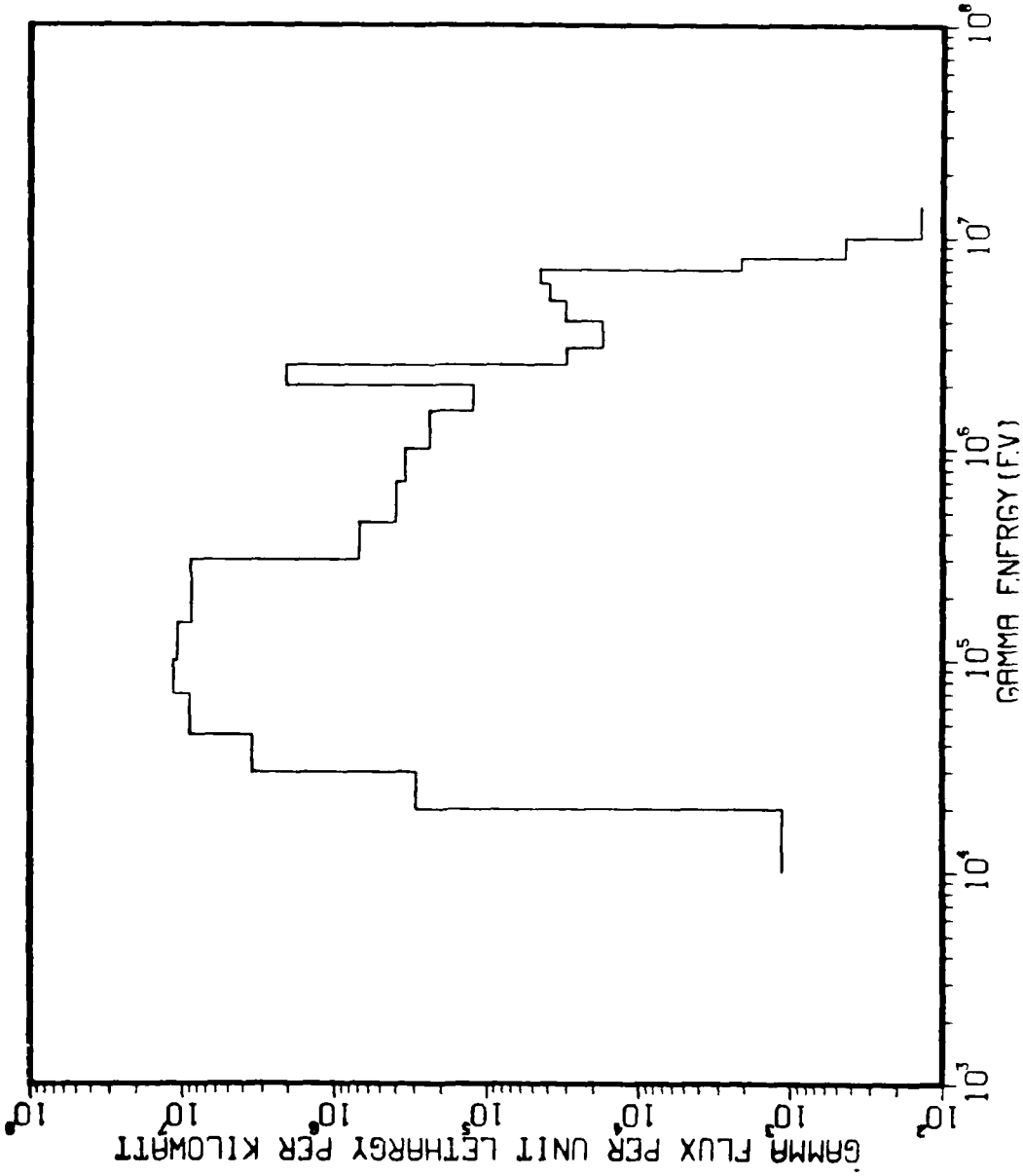

Figure II.6.34. Back Gamma Flux vs Energy Free Field ER1 400 CMS from Reactor.

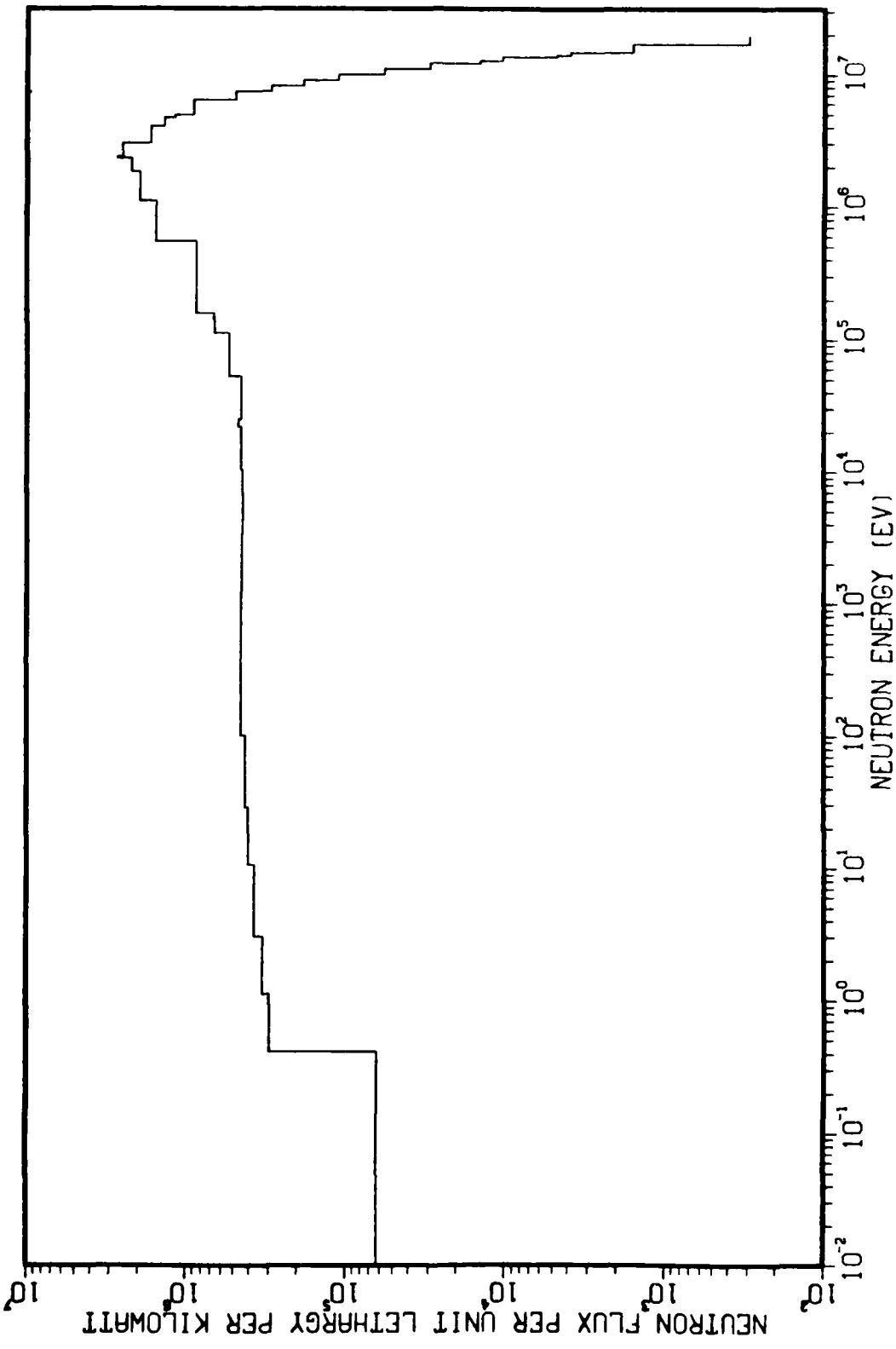

Figure II.6.35. Total Neutron Flux vs Energy Free Field ER1 400 CMS from Reactor.

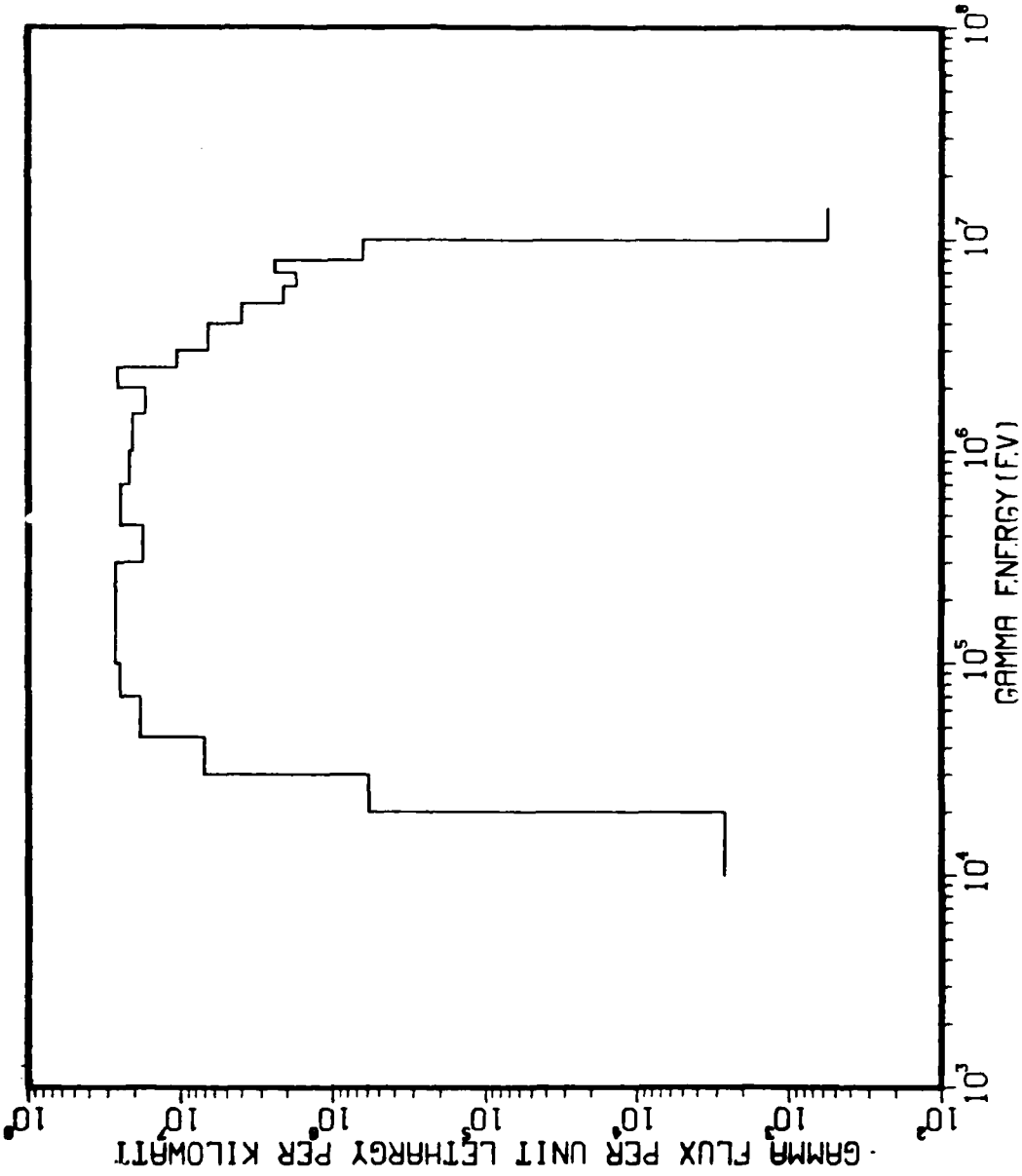

Figure II.6.36. Total Gamma Flux vs Energy Free Field ER1 400 CMS from Reactor.

Table II.6.9. Neutron Flux Per Unit Lethargy per Kilowatt.

ERI FREE FIELD 400 CMS FROM REACTOR

GROUP	ENERGY (EV)	FRONT	BACK	TOTAL
1	1.960E+07	2.95E+02	1.55E+00	2.97E+02
2	1.690E+07	1.58E+03	8.02E+00	1.59E+03
3	1.490E+07	3.89E+03	2.12E+01	3.92E+03
4	1.420E+07	4.69E+03	2.46E+01	4.72E+03
5	1.380E+07	1.03E+04	5.57E+01	1.04E+04
6	1.280E+07	1.43E+04	7.83E+01	1.44E+04
7	1.220E+07	2.93E+04	1.62E+02	2.95E+04
8	1.110E+07	5.67E+04	3.27E+02	5.71E+04
9	1.000E+07	1.11E+05	4.72E+02	1.12E+05
10	9.050E+06	1.84E+05	1.02E+03	1.85E+05
11	8.190E+06	2.93E+05	1.84E+03	2.95E+05
12	7.410E+06	4.86E+05	4.09E+03	4.91E+05
13	6.380E+06	8.91E+05	1.35E+04	9.05E+05
14	4.970E+06	1.15E+06	2.51E+04	1.18E+06
15	4.720E+06	1.35E+06	3.78E+04	1.38E+06
16	4.070E+06	1.60E+06	7.03E+04	1.67E+06
17	3.010E+06	2.29E+06	2.27E+05	2.52E+06
18	2.390E+06	2.54E+06	1.99E+05	2.74E+06
19	2.310E+06	2.05E+06	1.97E+05	2.24E+06
20	1.830E+06	1.78E+06	1.97E+05	1.98E+06
21	1.110E+06	1.34E+06	2.22E+05	1.56E+06
22	5.500E+05	7.04E+05	1.62E+05	8.66E+05
23	1.580E+05	5.33E+05	1.41E+05	6.74E+05
24	1.110E+05	4.20E+05	1.22E+05	5.42E+05
25	5.250E+04	3.41E+05	1.13E+05	4.54E+05
26	2.480E+04	3.59E+05	1.12E+05	4.71E+05
27	2.190E+04	3.40E+05	1.12E+05	4.53E+05
28	1.030E+04	3.26E+05	1.18E+05	4.44E+05
29	3.350E+03	3.22E+05	1.25E+05	4.47E+05
30	1.230E+03	3.22E+05	1.32E+05	4.54E+05
31	5.830E+02	3.13E+05	1.40E+05	4.53E+05
32	1.010E+02	2.82E+05	1.47E+05	4.28E+05
33	2.900E+01	2.60E+05	1.50E+05	4.10E+05
34	1.070E+01	2.24E+05	1.50E+05	3.74E+05
35	3.060E+00	1.80E+05	1.48E+05	3.28E+05
36	1.130E+00	1.55E+05	1.44E+05	2.99E+05
37	4.140E-01	8.08E+04	8.30E+04	6.37E+04

Table II.6.10. Gamma Flux per Unit Lethargy per Kilowatt.

ER1 FREE FIELD 400 CMS FROM REACTOR

GROUP	ENERGY (EV)	FRONT	BACK	TOTAL
1	1.400E+07	4.19E+02	1.39E+02	5.58E+02
2	1.000E+07	6.32E+05	4.41E+02	6.33E+05
3	8.000E+06	2.42E+06	2.13E+03	2.42E+06
4	7.000E+06	1.70E+06	4.54E+04	1.74E+06
5	6.000E+06	2.10E+06	3.96E+04	2.14E+06
6	5.000E+06	3.96E+06	3.10E+04	3.99E+06
7	4.000E+06	6.62E+06	1.77E+04	6.64E+06
8	3.000E+06	1.06E+07	3.06E+04	1.06E+07
9	2.500E+06	2.38E+07	2.08E+06	2.59E+07
10	2.000E+06	1.71E+07	1.25E+05	1.72E+07
11	1.500E+06	2.04E+07	2.41E+05	2.06E+07
12	1.000E+06	2.14E+07	3.49E+05	2.17E+07
13	7.000E+05	2.47E+07	3.97E+05	2.51E+07
14	4.500E+05	1.72E+07	6.95E+05	1.79E+07
15	3.000E+05	1.82E+07	8.69E+06	2.69E+07
16	1.500E+05	1.60E+07	1.08E+07	2.68E+07
17	1.000E+05	1.33E+07	1.15E+07	2.49E+07
18	7.000E+04	9.49E+06	8.99E+06	1.85E+07
19	4.500E+04	3.55E+06	3.49E+06	7.04E+06
20	3.000E+04	2.91E+05	2.96E+05	5.87E+05
21	2.000E+04	1.50E+03	1.16E+03	2.66E+03

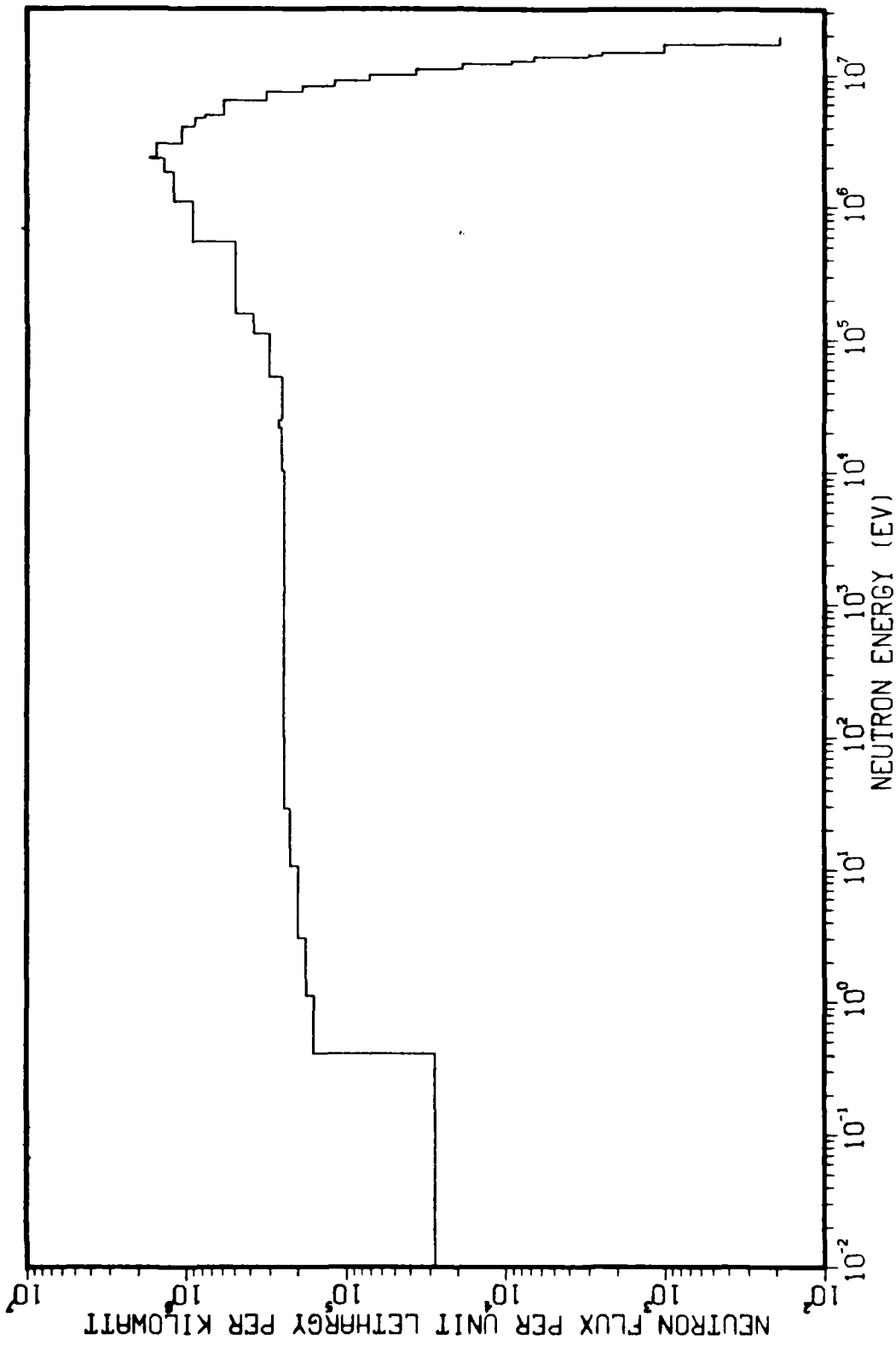

Figure II.6.37. Front Neutron Flux vs Energy Free Field ER1 500 CMS from Reactor.

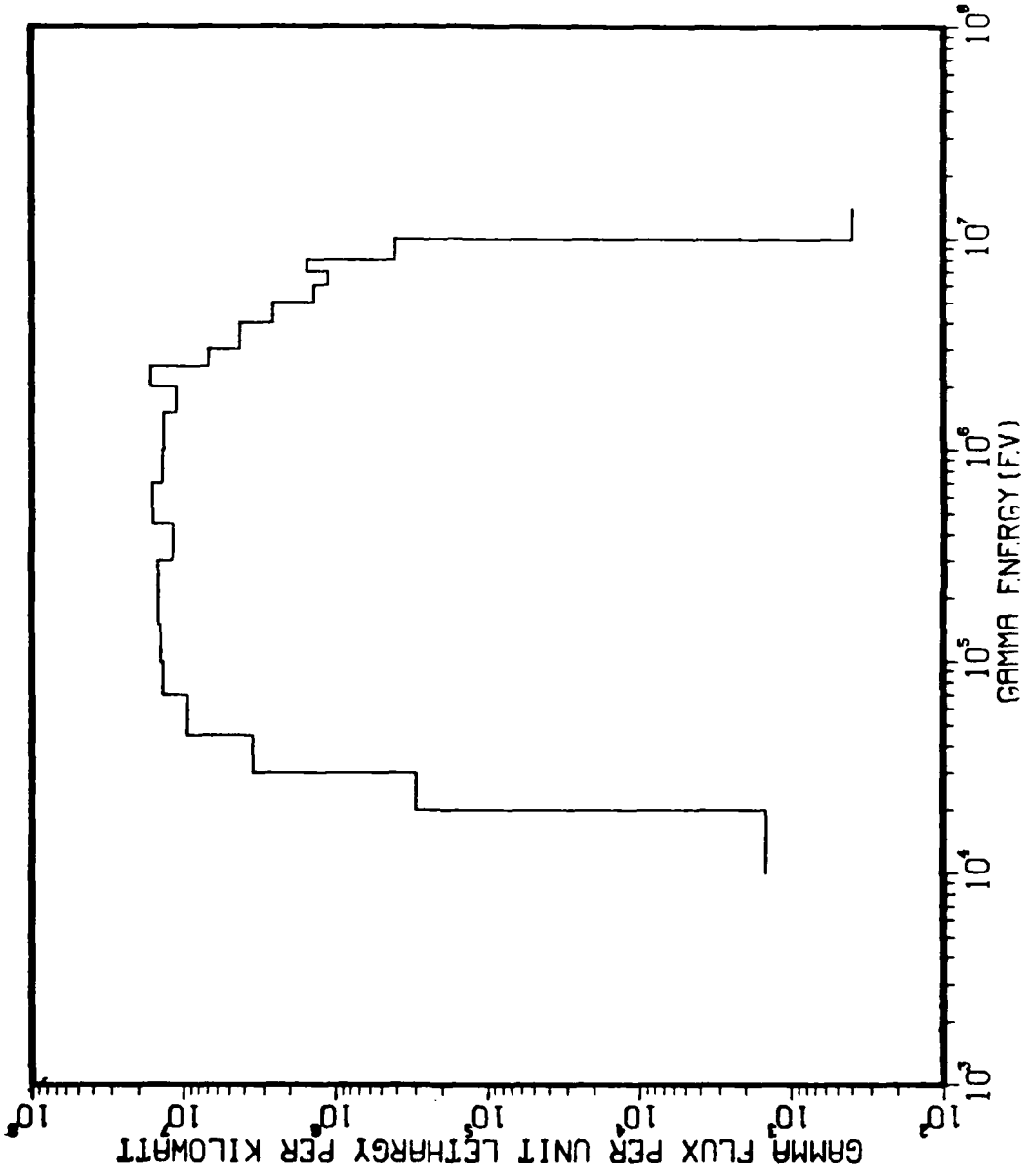

Figure II.6.38. Front Gamma Flux vs Energy Free Field ERI 500 CMS from Reactor.

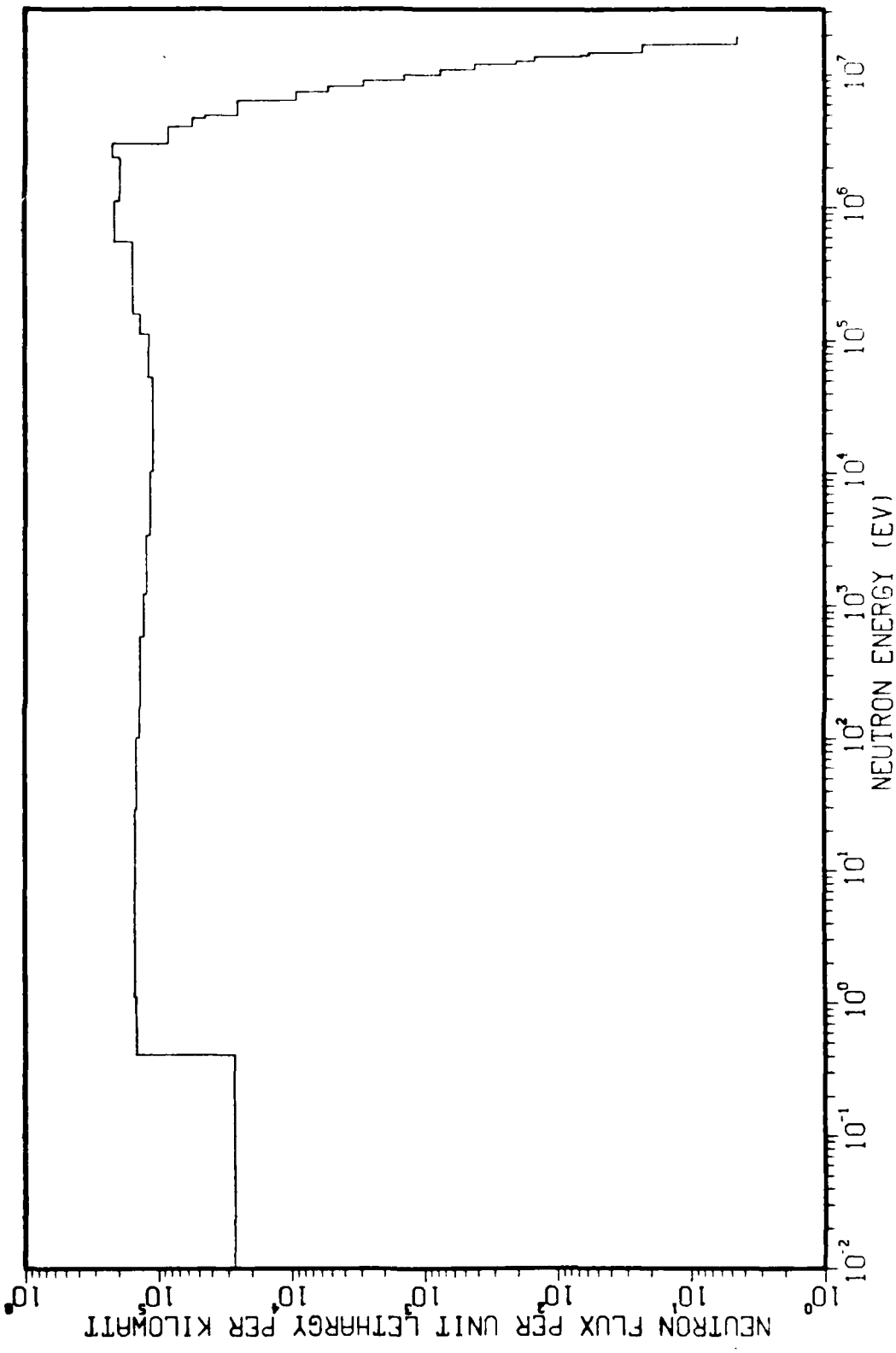

Figure II.6.39. Back Neutron Flux vs Energy Free Field ERI 500 CMS from Reactor.

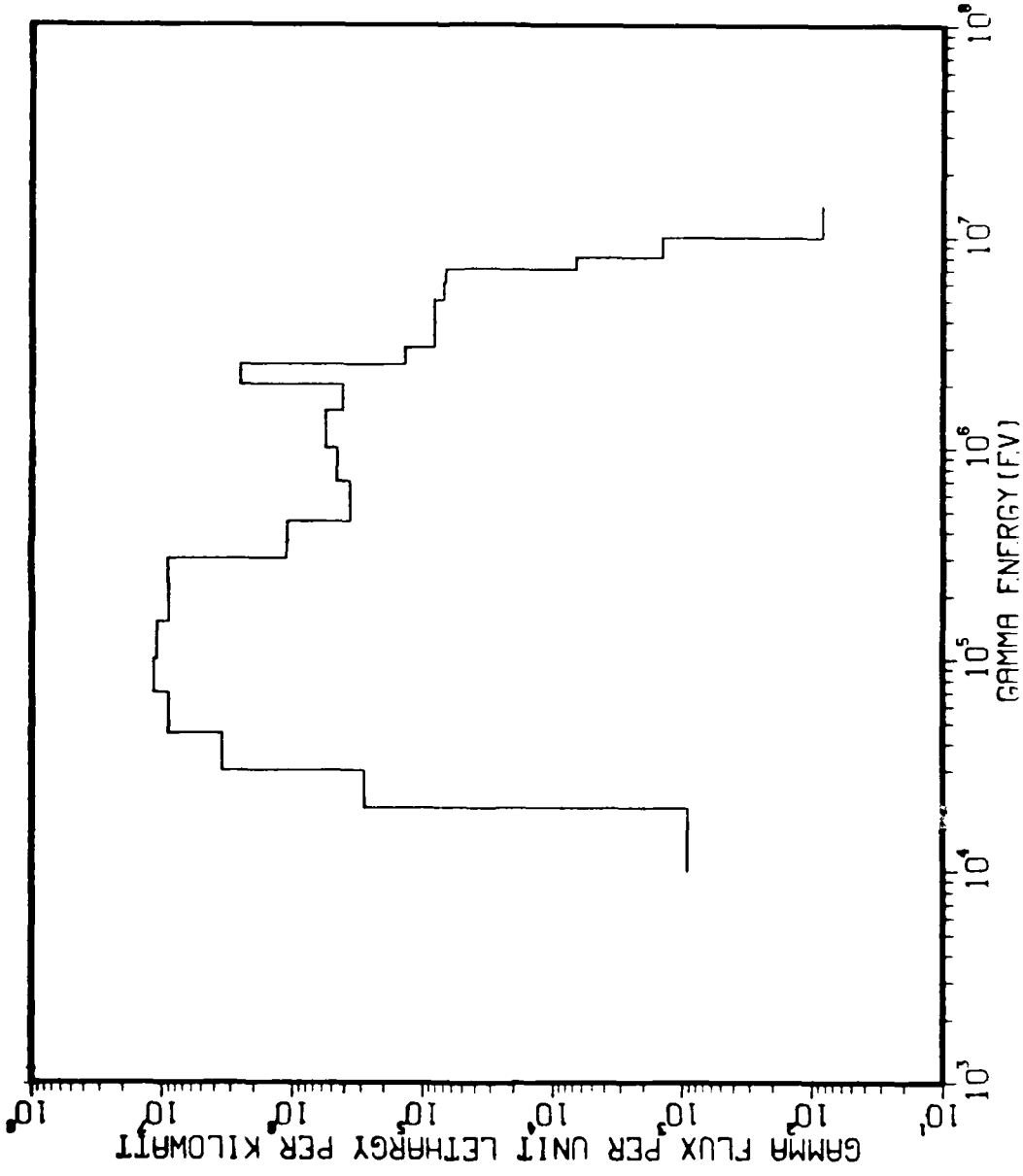

Figure II.6.40. Back Gamma Flux vs Energy Free Field ERI 500 CMS from Reactor.

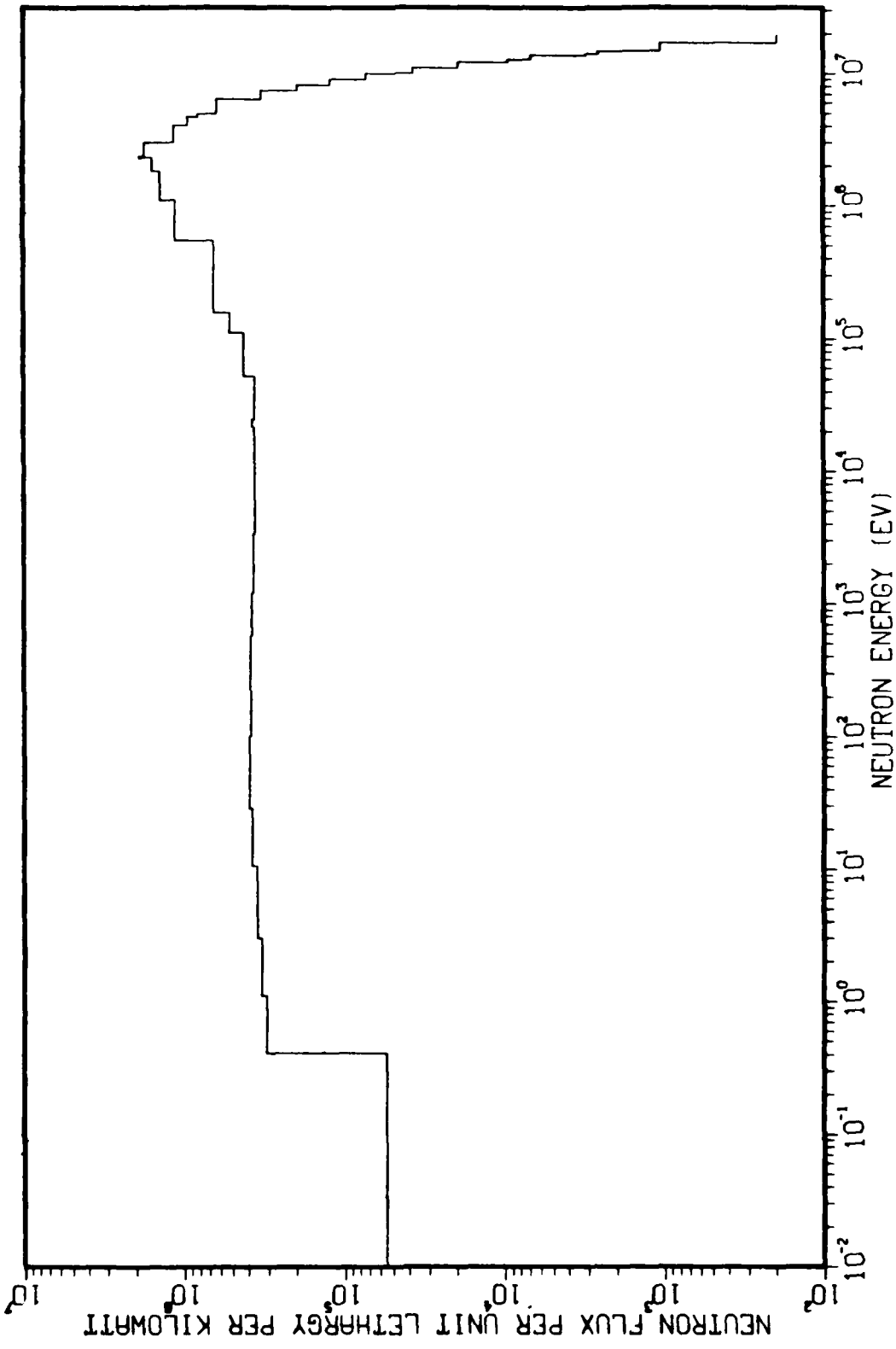

Figure II.6.41. Total Neutron Flux vs Energy Free Field ERI 500 CMS from Reactor.

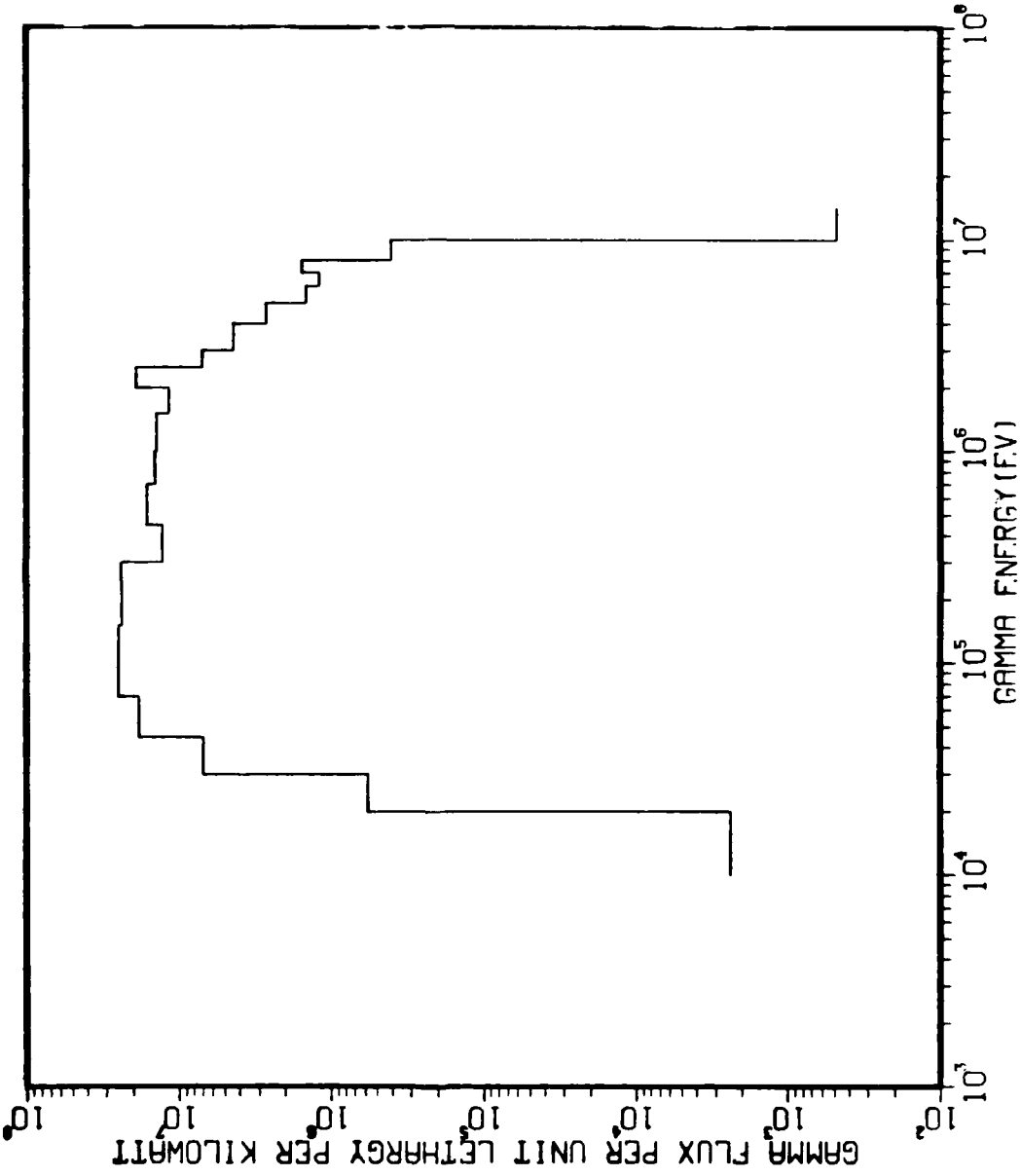

Figure II.6.42. Total Gamma Flux vs Energy Free Field ER1 500 CMS from Reactor.

Table II.6.11. Neutron Flux per Unit Lethargy per Kilowatt.

ER1 FREE FIELD 500 CMS FROM REACTOR

GROUP	ENERGY (EV)	FRONT	BACK	TOTAL
1	1.960E+07	1.90E+02	4.51E+00	1.95E+02
2	1.690E+07	1.02E+03	2.29E+01	1.04E+03
3	1.490E+07	2.51E+03	5.76E+01	2.56E+03
4	1.420E+07	3.02E+03	6.59E+01	3.08E+03
5	1.380E+07	6.63E+03	1.48E+02	6.78E+03
6	1.280E+07	9.20E+03	2.06E+02	9.41E+03
7	1.220E+07	1.89E+04	4.20E+02	1.93E+04
8	1.110E+07	3.66E+04	7.58E+02	3.73E+04
9	1.000E+07	7.15E+04	1.42E+03	7.29E+04
10	9.050E+06	1.19E+05	2.88E+03	1.22E+05
11	8.190E+06	1.90E+05	5.37E+03	1.95E+05
12	7.410E+06	3.17E+05	9.35E+03	3.27E+05
13	6.380E+06	5.88E+05	2.58E+04	6.14E+05
14	4.970E+06	7.64E+05	4.47E+04	8.09E+05
15	4.720E+06	8.90E+05	5.58E+04	9.46E+05
16	4.070E+06	1.06E+06	8.56E+04	1.15E+06
17	3.010E+06	1.53E+06	2.22E+05	1.75E+06
18	2.390E+06	1.68E+06	1.99E+05	1.88E+06
19	2.310E+06	1.36E+06	1.95E+05	1.56E+06
20	1.830E+06	1.19E+06	1.95E+05	1.39E+06
21	1.110E+06	9.12E+05	2.13E+05	1.12E+06
22	5.500E+05	4.95E+05	1.55E+05	6.50E+05
23	1.580E+05	3.81E+05	1.37E+05	5.18E+05
24	1.110E+05	3.05E+05	1.19E+05	4.23E+05
25	5.250E+04	2.52E+05	1.10E+05	3.62E+05
26	2.480E+04	2.64E+05	1.10E+05	3.74E+05
27	2.190E+04	2.52E+05	1.10E+05	3.63E+05
28	1.030E+04	2.45E+05	1.16E+05	3.61E+05
29	3.350E+03	2.45E+05	1.23E+05	3.68E+05
30	1.230E+03	2.48E+05	1.30E+05	3.78E+05
31	5.830E+02	2.46E+05	1.38E+05	3.84E+05
32	1.010E+02	2.45E+05	1.46E+05	3.90E+05
33	2.900E+01	2.26E+05	1.49E+05	3.75E+05
34	1.070E+01	2.01E+05	1.50E+05	3.51E+05
35	3.060E+00	1.80E+05	1.49E+05	3.29E+05
36	1.130E+00	1.61E+05	1.46E+05	3.07E+05
37	4.140E-01	2.79E+04	2.71E+04	5.49E+04

Table II.6.12. Gamma Flux per Unit Lethargy per Kilowatt.

ER1 FREE FIELD 500 CMS FROM REACTOR

GROUP	ENERGY (EV)	FRONT	BACK	TOTAL
1	1.400E+07	3.92E+02	8.40E+01	4.76E+02
2	1.000E+07	4.03E+05	1.46E+03	4.05E+05
3	8.000E+06	1.54E+06	6.73E+03	1.55E+06
4	7.000E+06	1.12E+06	6.76E+04	1.19E+06
5	6.000E+06	1.38E+06	7.00E+04	1.45E+06
6	5.000E+06	2.58E+06	8.30E+04	2.67E+06
7	4.000E+06	4.28E+06	8.30E+04	4.36E+06
8	3.000E+06	6.83E+06	1.40E+05	6.97E+06
9	2.500E+06	1.64E+07	2.55E+06	1.89E+07
10	2.000E+06	1.11E+07	4.18E+05	1.15E+07
11	1.500E+06	1.34E+07	5.66E+05	1.40E+07
12	1.000E+06	1.39E+07	4.63E+05	1.43E+07
13	7.000E+05	1.59E+07	3.66E+05	1.63E+07
14	4.500E+05	1.17E+07	1.11E+06	1.28E+07
15	3.000E+05	1.47E+07	8.92E+06	2.36E+07
16	1.500E+05	1.41E+07	1.09E+07	2.51E+07
17	1.000E+05	1.36E+07	1.16E+07	2.51E+07
18	7.000E+04	9.35E+06	8.92E+06	1.83E+07
19	4.500E+04	3.48E+06	3.45E+06	6.93E+06
20	3.000E+04	2.96E+05	2.82E+05	5.79E+05
21	2.000E+04	1.47E+03	9.26E+02	2.40E+03

Table II.6.13. Front Response as a Function of Distance in ER1.

Response	Distance from Reactor in ER1 (cms)					
	50	100	200	300	400	500
Sulfur Activation (acts/cc-s/atom/bn·cm/kW)	2.44+7	5.70+6	1.38+6	6.15+5	3.51+5	2.32+5
Silicon Damage (1 MeV Equivalent n/cm^2-s/kW)	3.92+8	9.10+7	2.23+7	1.02+7	6.06+6	4.11+6
Neutron Dose (rads/s/kW)	1.25+0	2.91-1	7.17-2	3.32-2	1.99-2	1.37-2
Gamma Dose (rad/s/kW)	2.06+0	4.81-1	1.17-1	5.24-2	3.03-2	2.03-2
Neutron Dose (rem/s/kW)	1.10+1	2.55+0	6.22-1	2.84-1	1.69-1	1.14-1
Total Dose (rad/s/kW)	3.32+0	7.72-1	1.89-1	8.56-2	5.02-2	3.41-2
Total Dose (rem/s/kW)	1.30+1	3.03+0	7.39-1	3.37-1	1.99-1	1.35-1
Total Neutron Flux (n/cm^2-s/kW)	4.76+8	1.11+8	2.86+7	1.41+7	9.07+6	6.71+6
Neutron Flux >1 MeV (n/cm^2-s/kW)	2.20+8	5.13+7	1.25+7	5.62+6	3.28+6	2.18+6

Table II.6.14. Back Response as a Function of Distance in ER1.

Response	Distance from Reactor in ER1 (cms)					
	50	100	200	300	400	500
Sulfur Activation (acts/cc-s/atom/bn·cm/kW)	2.69+4	1.68+4	1.22+4	1.28+4	1.46+4	1.77+4
Silicon Damage (1 MeV Equivalent n/cm^2-s/kW)	1.41+6	1.03+6	8.35+5	7.77+5	7.65+5	7.55+5
Neutron Dose (rads/s/kW)	5.34-3	4.04-3	3.33-3	3.11-3	3.02-3	3.00-3
Gamma Dose (rad/s/kW)	2.11-3	1.86-3	1.79-3	1.87-3	2.05-3	2.41-3
Neutron Dose (rem/s/kW)	3.89-2	2.82-2	2.26-2	2.09-2	2.04-2	2.03-2
Total Dose (rad/s/kW)	7.45-3	5.90-3	5.12-3	4.98-3	5.07-3	5.41-3
Total Dose (rem/s/kW)	4.10-2	3.01-2	2.44-2	2.28-2	2.24-2	2.27-2
Total Neutron Flux (n/cm^2-s/kW)	4.46+6	3.58+6	3.08+6	2.87+6	2.76+6	2.66+6
Neutron Flux >1 MeV (n/cm^2-s/kW)	5.32+5	3.67+5	2.84+5	2.68+5	2.67+5	2.76+5

Table II.6.15. Total Response as a Function of Distance in ER1.

Response	Distance from Reactor in ER1 (cms)					
	50	100	200	300	400	500
Sulfur Activation (acts/cc-s/atom/bn•cm/kW)	2.44+7	5.72+6	1.40+6	6.28+5	3.65+5	2.49+5
Silicon Damage (1 MeV Equivalent n/cm^2-s/kW)	3.93+8	9.20+7	2.31+7	1.10+7	6.82+6	4.87+6
Neutron Dose (rads/s/kW)	1.26+0	2.95-1	7.51-2	3.63-2	2.30-2	1.67-2
Gamma Dose (rad/s/kW)	2.07+0	4.83-1	1.19-1	5.43-2	3.23-2	2.28-2
Neutron Dose (rem/s/kW)	1.10+1	2.58+0	6.45-1	3.05-1	1.89-1	1.35-1
Total Dose (rad/s/kW)	3.32+0	7.78-1	1.94-1	9.06-2	5.53-2	3.95-2
Total Dose (rem/s/kW)	1.31+1	3.06+0	7.64-1	3.59-1	2.22-1	1.57-1
Total Neutron Flux (n/cm^2-s/kW)	4.81+8	1.15+8	3.17+7	1.70+7	1.18+7	9.37+6
Neutron Flux >1 MeV (n/cm^2-s/kW)	2.21+8	5.17+7	1.28+7	5.89+6	3.54+6	2.46+6

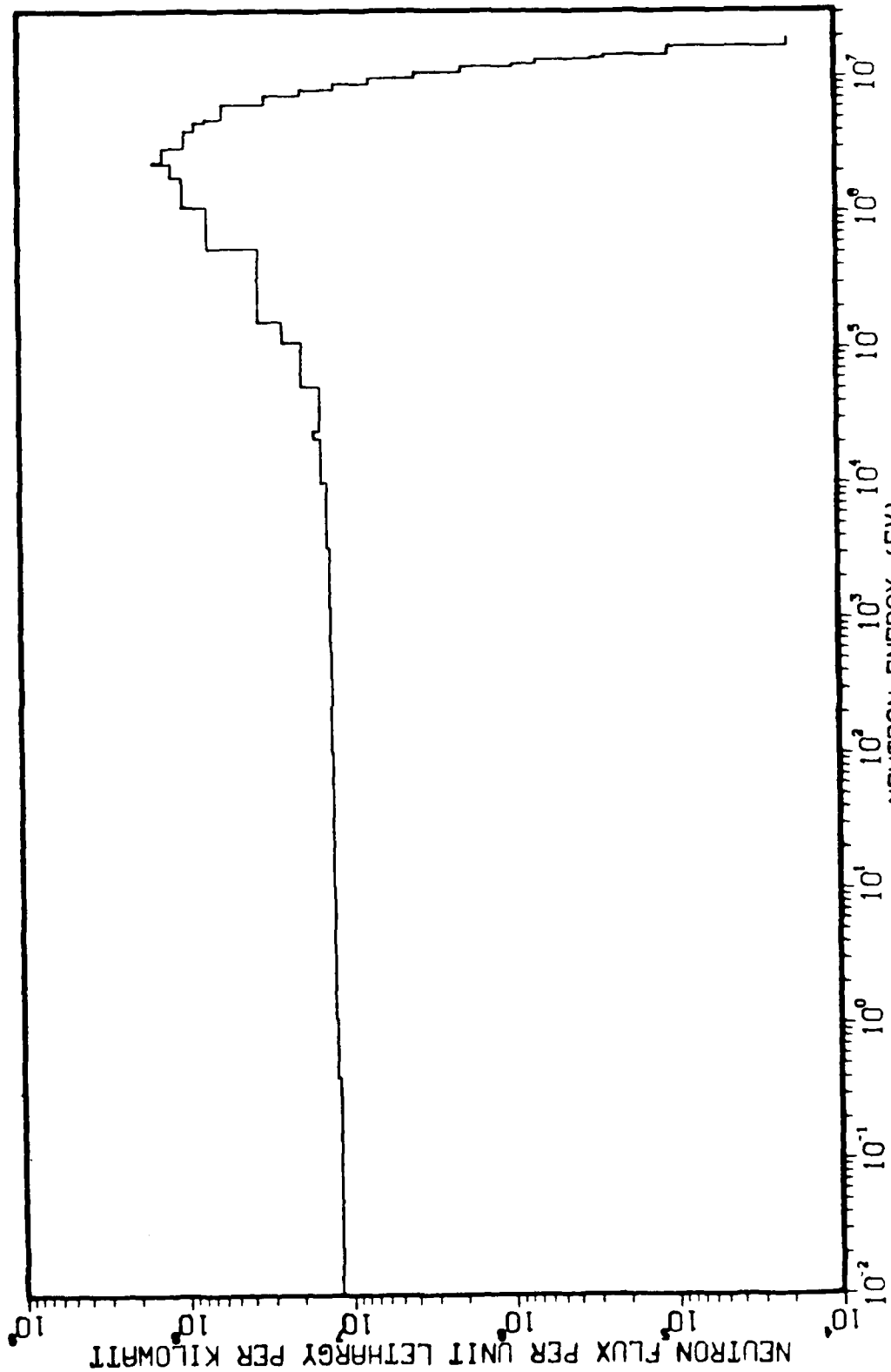

Figure II.6.43. Front (1-D) Neutron Flux vs Energy Free Field ER2 50 cms from Reactor.

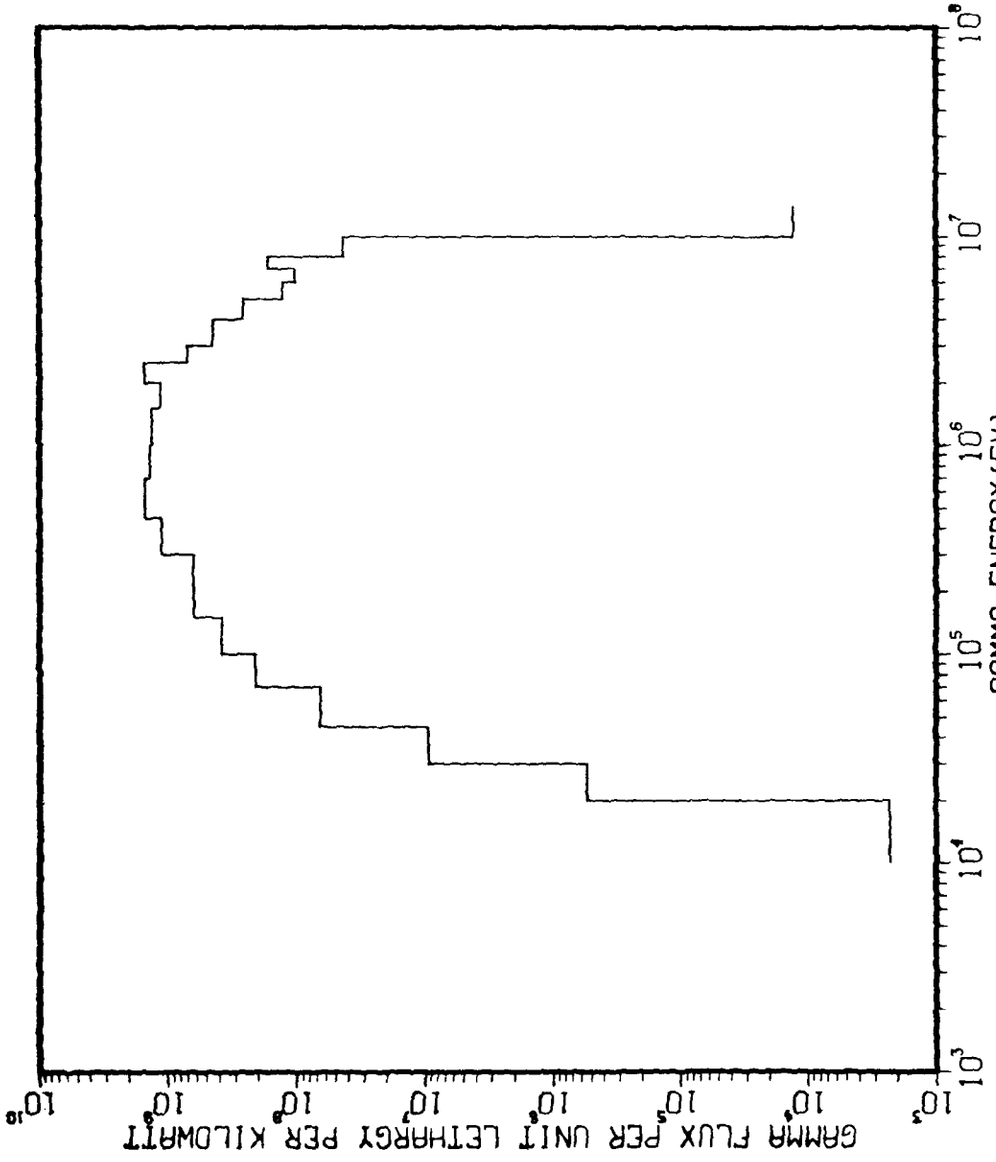

Figure II.6.44. Front Gamma Flux vs Energy Free Field ER2 50 cms from Reactor.

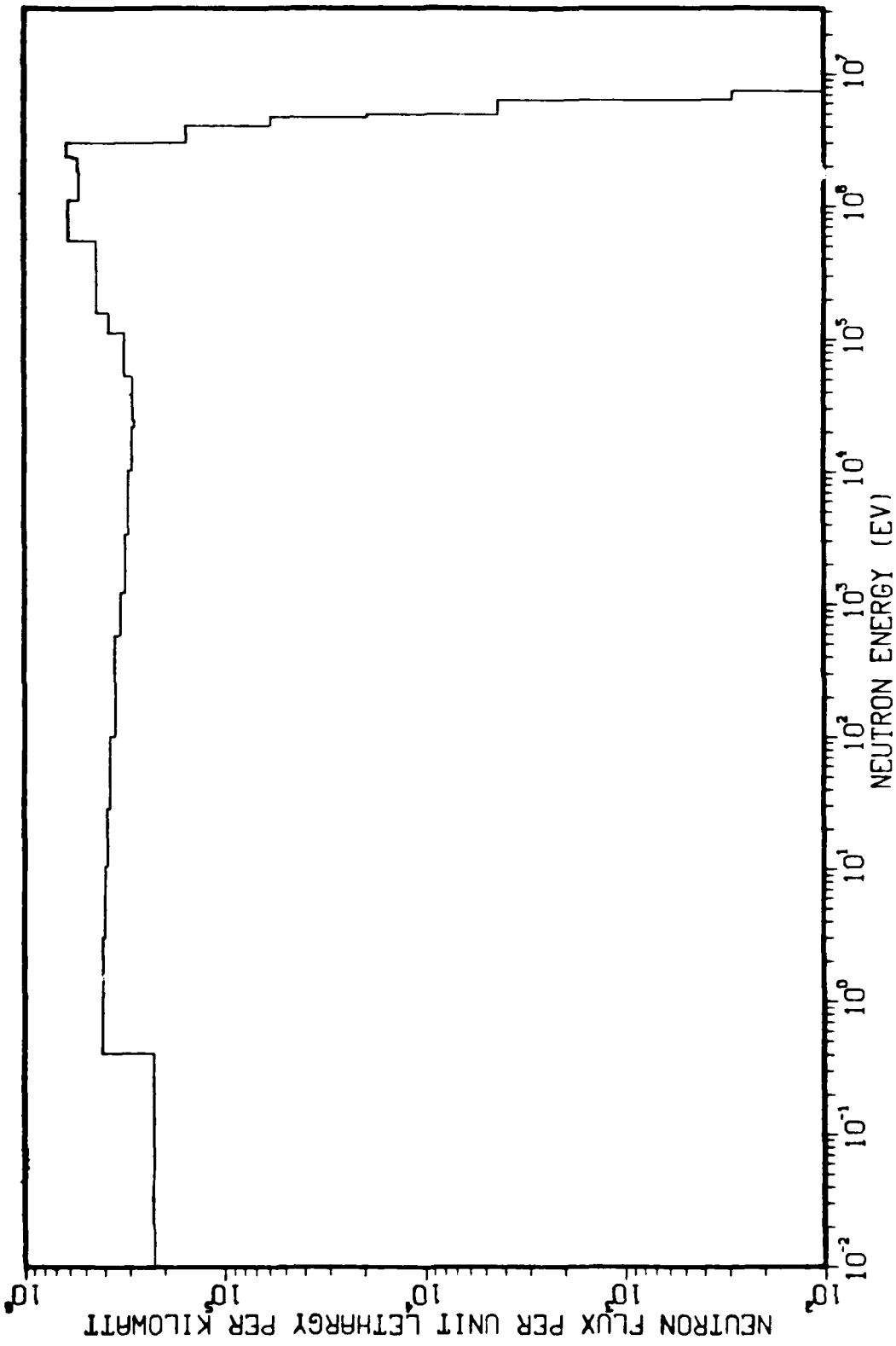

Figure II.6.45. Back (1-D) Neutron Flux vs Energy Free Field ER2 50 cms from Reactor.

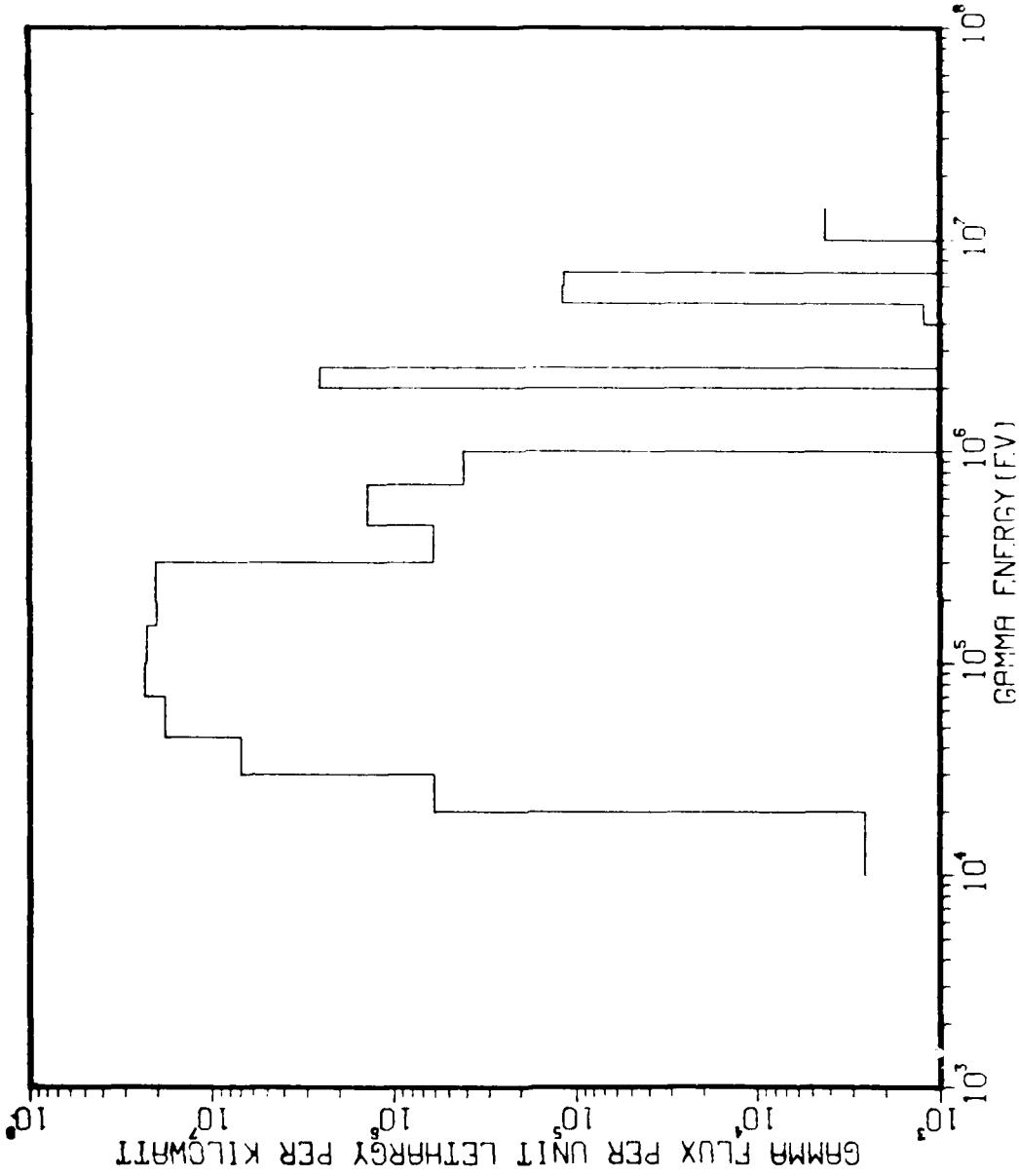

Figure II.6.46. Back Gamma Flux vs Energy Free Field ER2 50 cms from Reactor.

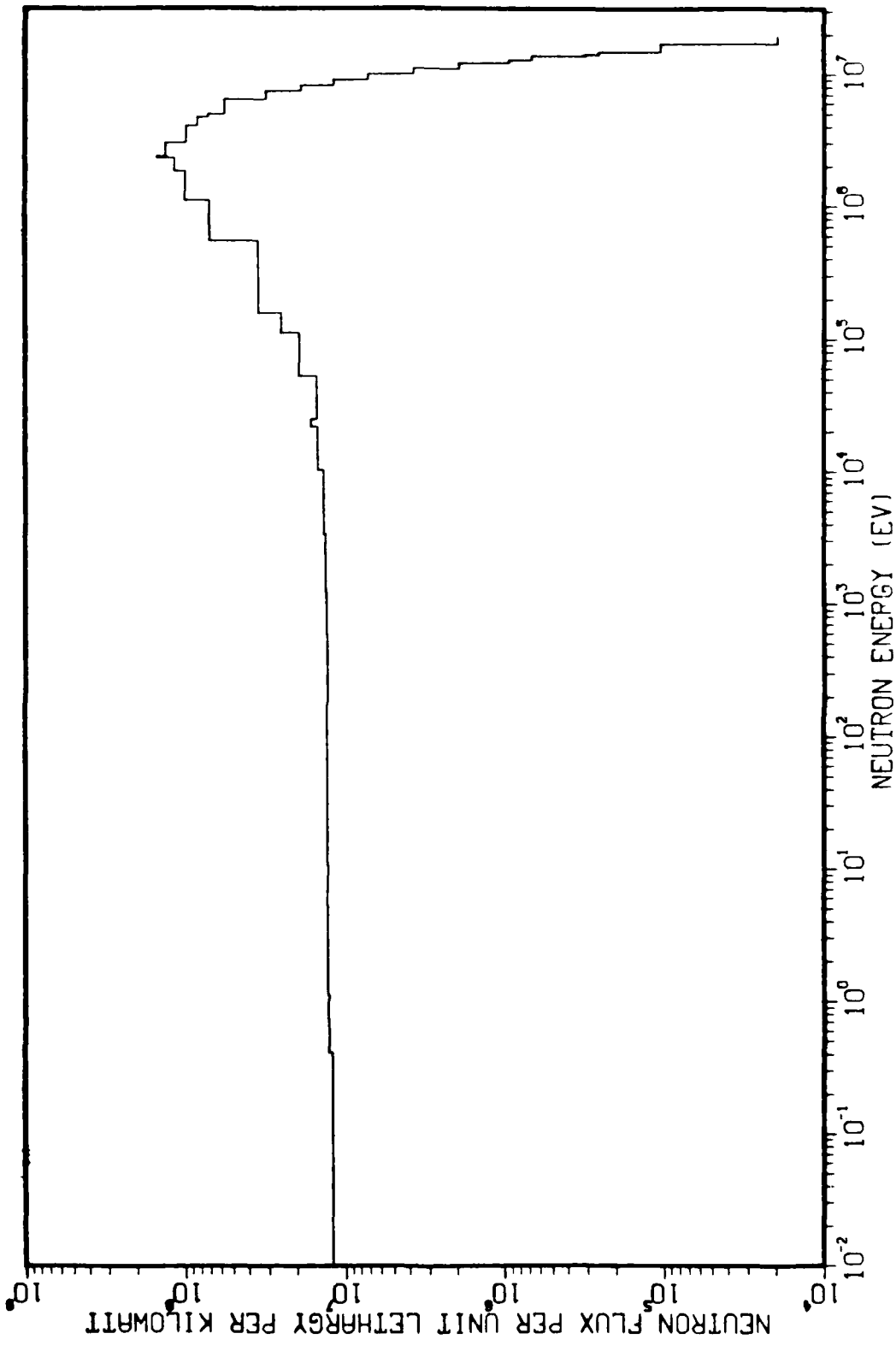

Figure II.6.47. Total (Front+Back, 1-D) Neutron Flux vs Energy Free Field ER2 50 cms from Reactor.

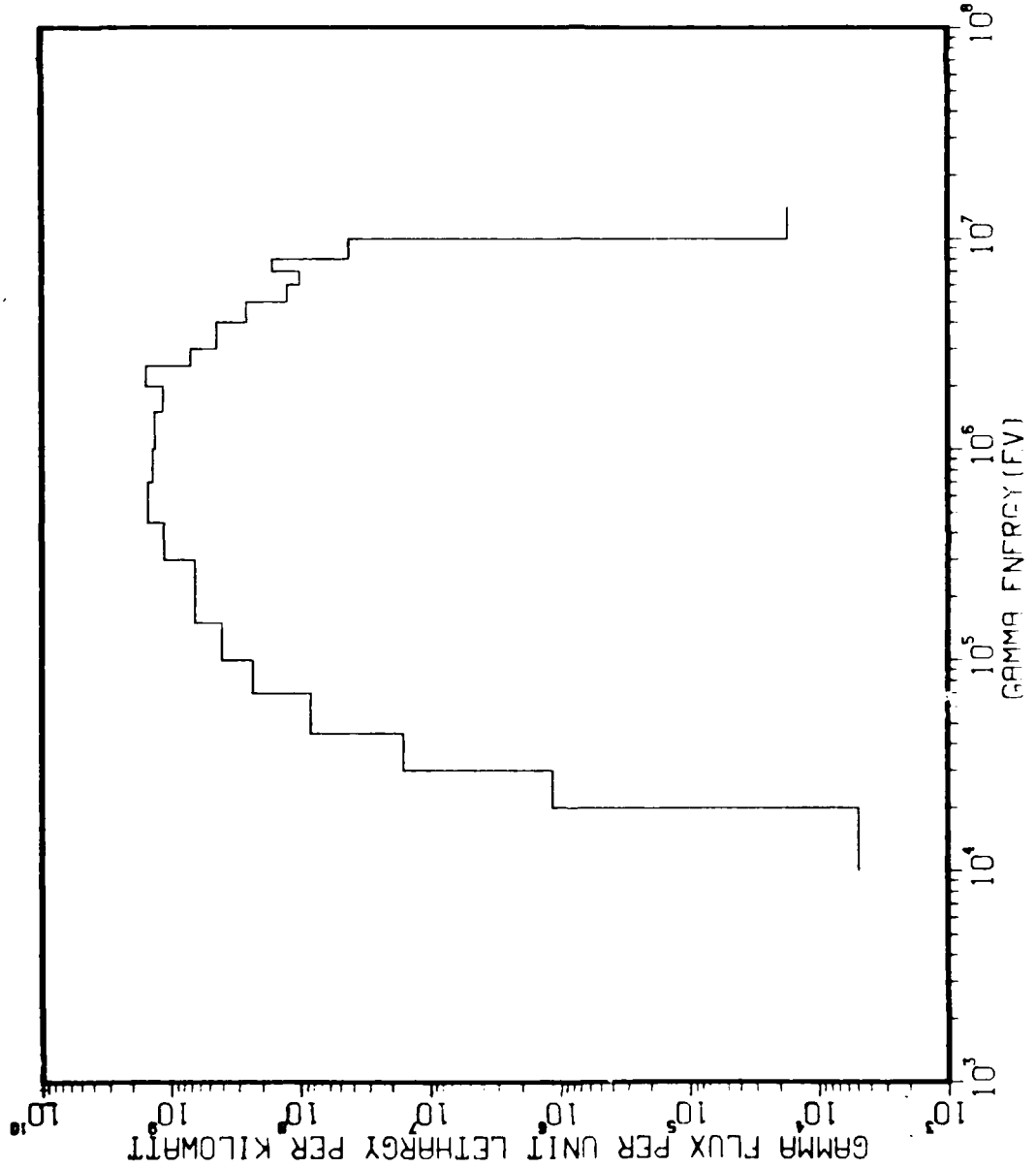

Figure II.6.48. Total (Front+Back) Gamma Flux vs Energy Free Field ER2 50 cms from Reactor.

Table II.6.16. Neutron Flux per Unit Lethargy per Kilowatt.

ER2 FREE FIELD 50 CMS FROM REACTOR

GROUP	ENERGY (EV)	FRONT	BACK	TOTAL
1	1.960E+07	1.95E+04	0.00E+00	1.95E+04
2	1.690E+07	1.04E+05	0.00E+00	1.04E+05
3	1.490E+07	2.56E+05	0.00E+00	2.56E+05
4	1.420E+07	3.08E+05	0.00E+00	3.08E+05
5	1.380E+07	6.75E+05	0.00E+00	6.75E+05
6	1.280E+07	9.36E+05	0.00E+00	9.36E+05
7	1.220E+07	1.91E+06	0.00E+00	1.91E+06
8	1.110E+07	3.70E+06	0.00E+00	3.70E+06
9	1.000E+07	7.18E+06	0.00E+00	7.18E+06
10	9.050E+06	1.18E+07	0.00E+00	1.18E+07
11	8.190E+06	1.89E+07	0.00E+00	1.89E+07
12	7.410E+06	3.11E+07	2.89E+02	3.11E+07
13	6.380E+06	5.65E+07	4.27E+03	5.65E+07
14	4.970E+06	7.19E+07	1.92E+04	7.19E+07
15	4.720E+06	8.39E+07	5.83E+04	8.39E+07
16	4.070E+06	9.75E+07	1.53E+05	9.77E+07
17	3.010E+06	1.32E+08	6.11E+05	1.32E+08
18	2.390E+06	1.50E+08	5.71E+05	1.50E+08
19	2.310E+06	1.17E+08	5.36E+05	1.17E+08
20	1.830E+06	9.98E+07	5.28E+05	1.00E+08
21	1.110E+06	7.04E+07	5.98E+05	7.10E+07
22	5.500E+05	3.46E+07	4.32E+05	3.51E+07
23	1.580E+05	2.49E+07	3.78E+05	2.53E+07
24	1.110E+05	1.92E+07	3.14E+05	1.95E+07
25	5.250E+04	1.48E+07	2.87E+05	1.51E+07
26	2.480E+04	1.60E+07	2.81E+05	1.63E+07
27	2.190E+04	1.46E+07	2.89E+05	1.49E+07
28	1.030E+04	1.34E+07	3.01E+05	1.37E+07
29	3.350E+03	1.30E+07	3.15E+05	1.33E+07
30	1.230E+03	1.29E+07	3.32E+05	1.32E+07
31	5.830E+02	1.27E+07	3.53E+05	1.31E+07
32	1.010E+02	1.27E+07	3.74E+05	1.31E+07
33	2.900E+01	1.27E+07	3.86E+05	1.30E+07
34	1.070E+01	1.25E+07	3.96E+05	1.29E+07
35	3.060E+00	1.25E+07	4.05E+05	1.29E+07
36	1.130E+00	1.22E+07	4.08E+05	1.26E+07
37	4.140E-01	1.18E+07	2.27E+05	1.21E+07

Table II.6.17. Gamma Flux per Unit Lethargy per Kilowatt.

ER2 FREE FIELD 50 CMS FROM REACTOR

GROUP	ENERGY (EV)	FRONT	BACK	TOTAL
1	1.400E+07	1.30E+04	4.27E+03	1.73E+04
2	1.000E+07	4.26E+07	0.00E+00	4.26E+07
3	8.000E+06	1.66E+08	0.00E+00	1.66E+08
4	7.000E+06	1.01E+08	1.15E+05	1.01E+08
5	6.000E+06	1.28E+08	1.17E+05	1.28E+08
6	5.000E+06	2.60E+08	1.22E+03	2.60E+08
7	4.000E+06	4.40E+08	0.00E+00	4.40E+08
8	3.000E+06	7.03E+08	0.00E+00	7.03E+08
9	2.500E+06	1.54E+09	2.53E+06	1.54E+09
10	2.000E+06	1.14E+09	0.00E+00	1.14E+09
11	1.500E+06	1.33E+09	0.00E+00	1.33E+09
12	1.000E+06	1.39E+09	4.13E+05	1.39E+09
13	7.000E+05	1.50E+09	1.39E+06	1.50E+09
14	4.500E+05	1.12E+09	6.02E+05	1.12E+09
15	3.000E+05	6.33E+08	2.02E+07	6.53E+08
16	1.500E+05	3.82E+08	2.29E+07	4.05E+08
17	1.000E+05	2.10E+08	2.34E+07	2.33E+08
18	7.000E+04	6.59E+07	1.80E+07	8.38E+07
19	4.500E+04	9.43E+06	6.89E+06	1.63E+07
20	3.000E+04	5.40E+05	6.03E+05	1.14E+06
21	2.000E+04	2.31E+03	2.57E+03	4.88E+03

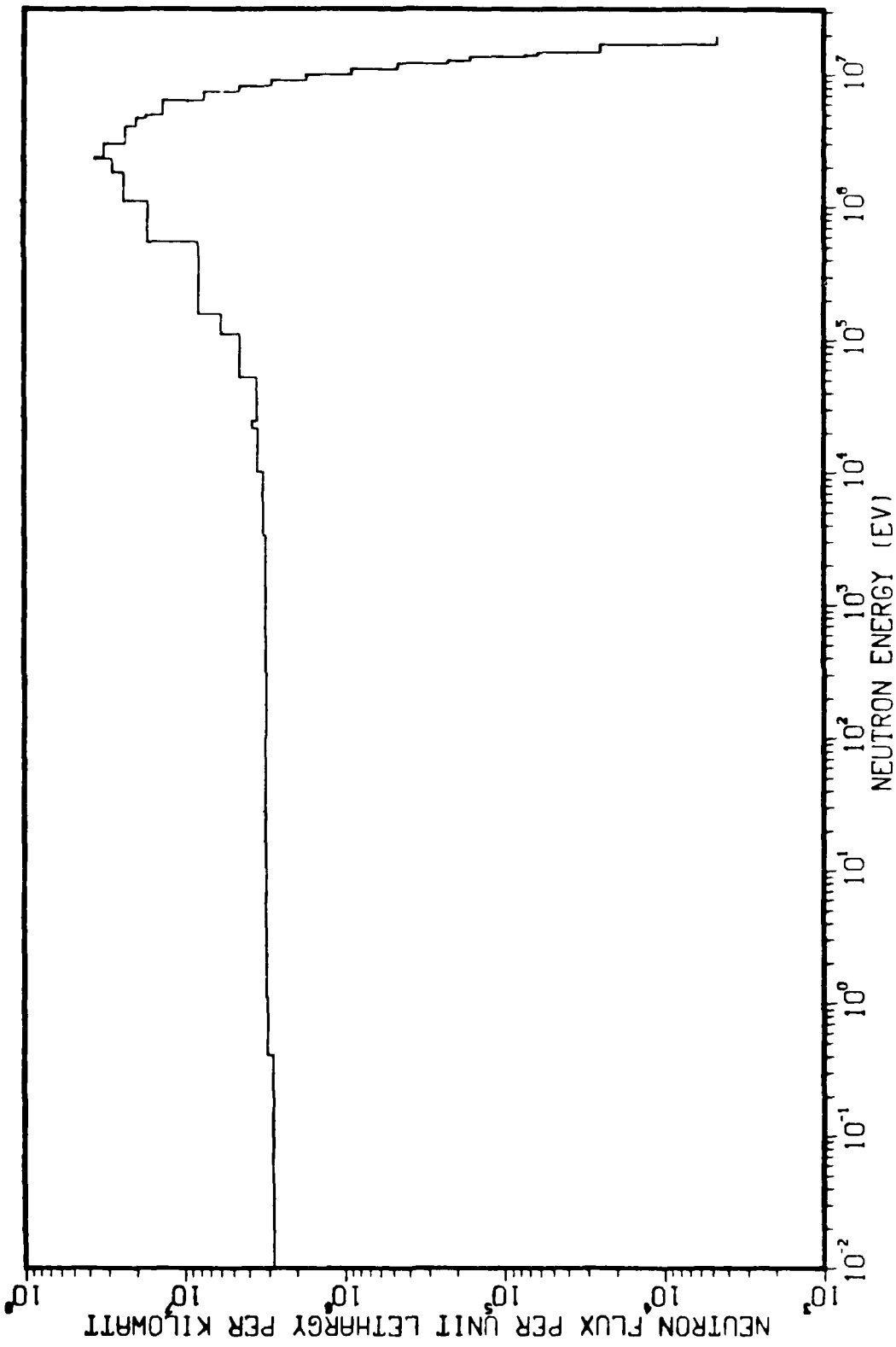

Figure II.6.49. Front (1-D) Neutron Flux vs Energy Free Field ER2 100 cms from Reactor.

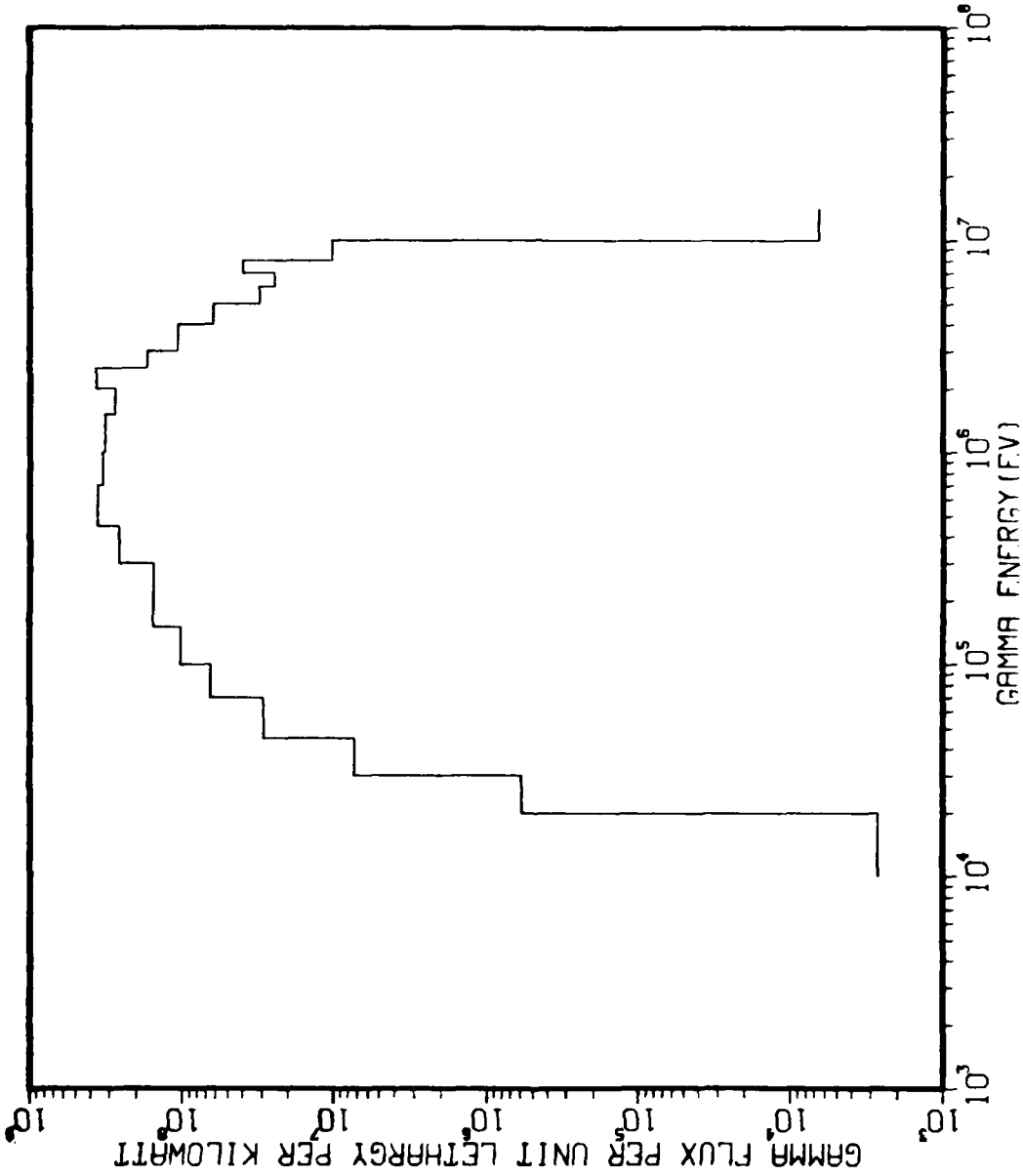

Figure II.6.50. Front Gamma Flux vs Energy Free Field ER2 100 cms from Reactor.

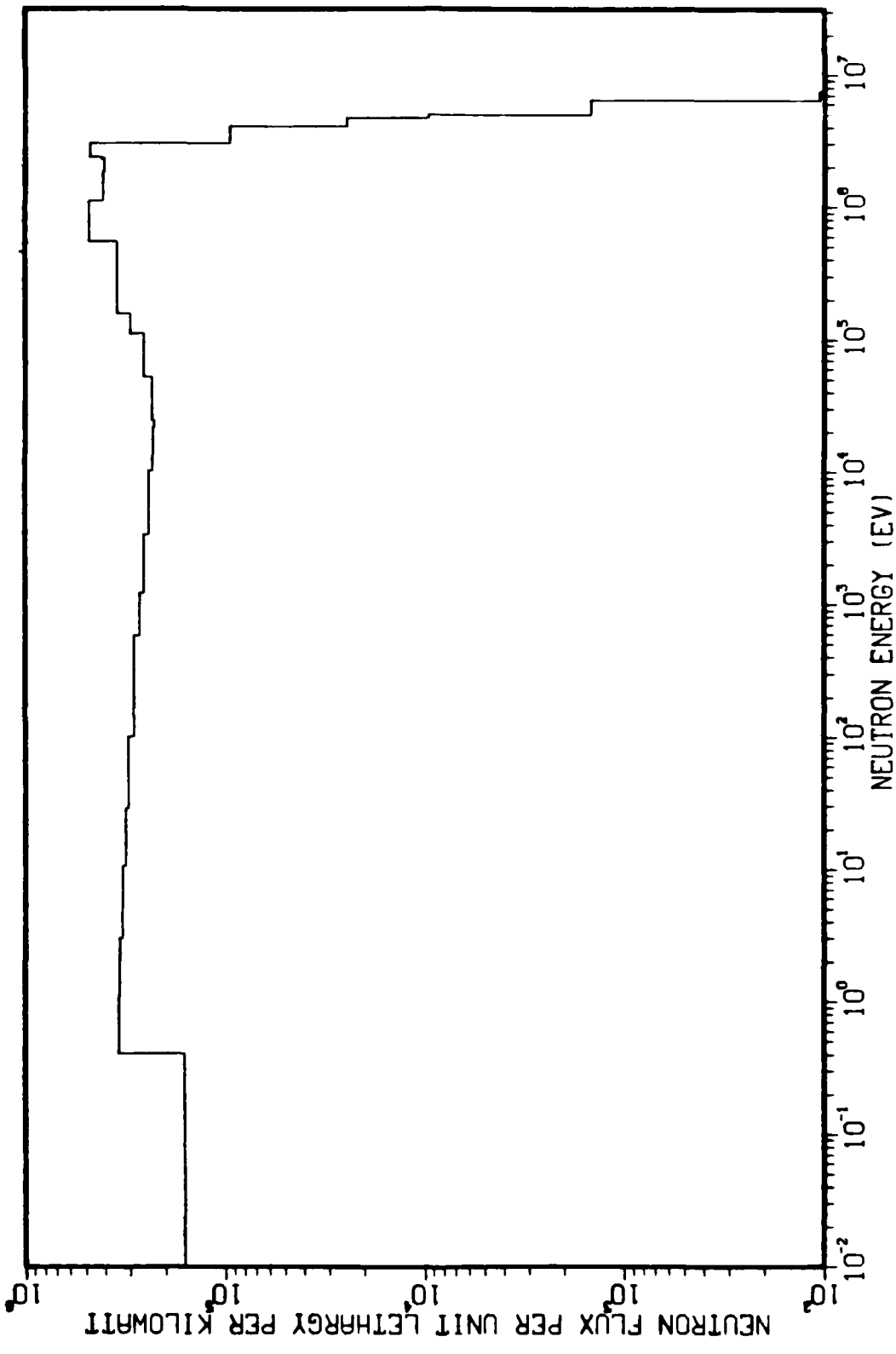

Figure II.6.51. Back (1-D) Neutron Flux vs Energy Free Field ER2 100 cms from Reactor.

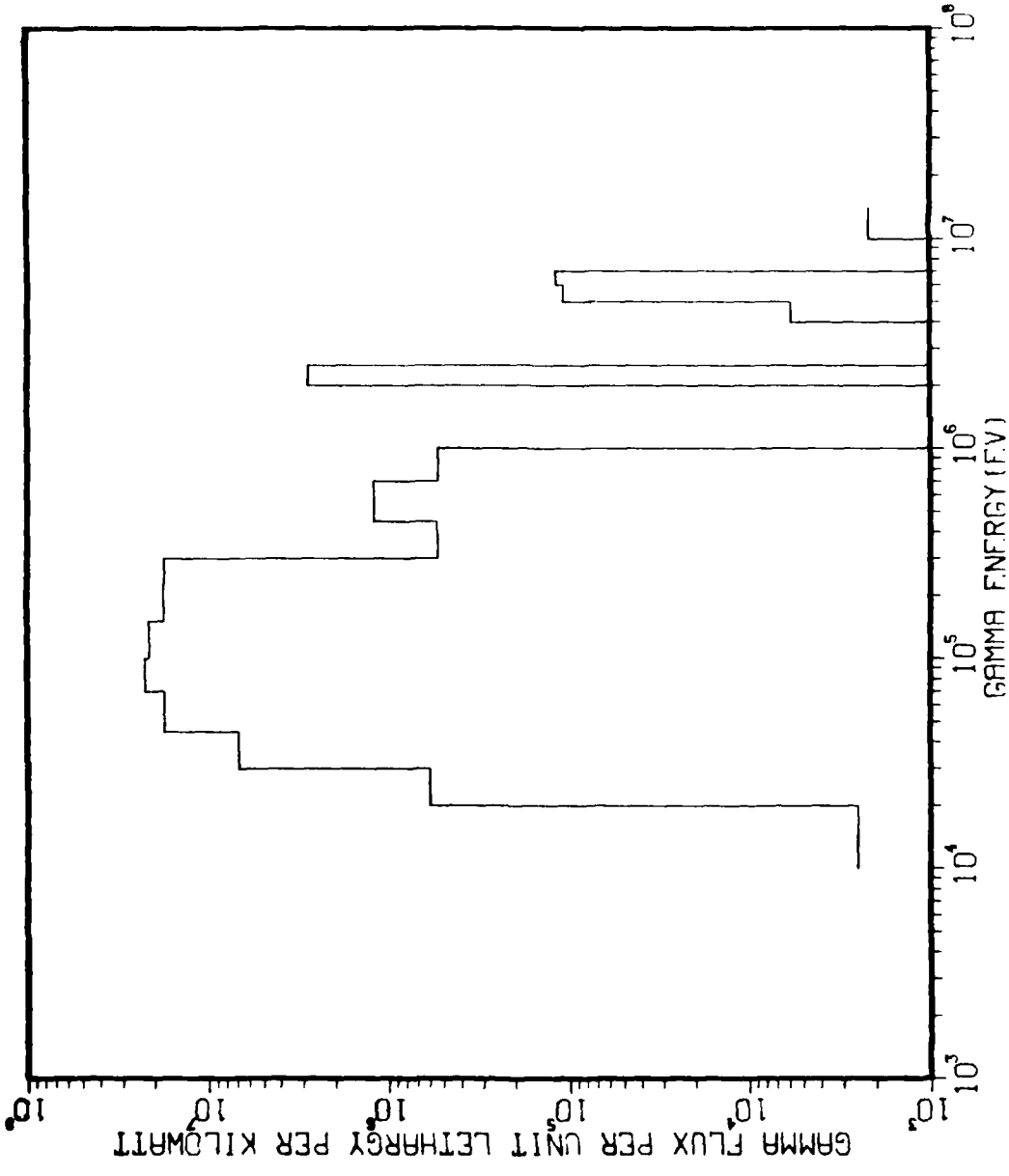

Figure II.6.52. Back Gamma Flux vs Energy Free Field ER2 100 cms from Reactor.

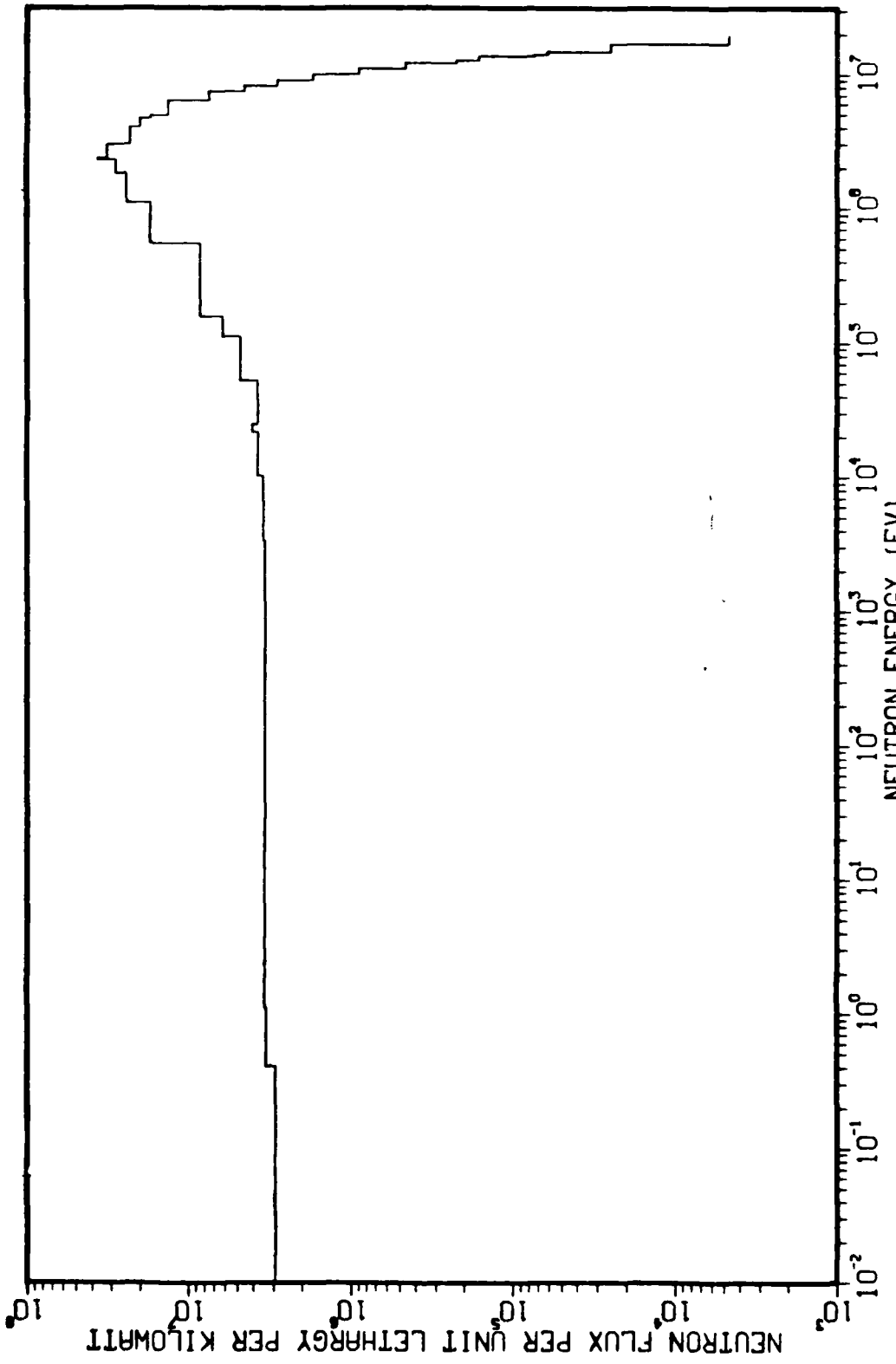

Figure II.6.53. Total (Front+Back, 1-D) Neutron Flux vs Energy Free Field ER2 100 cms from Reactor.

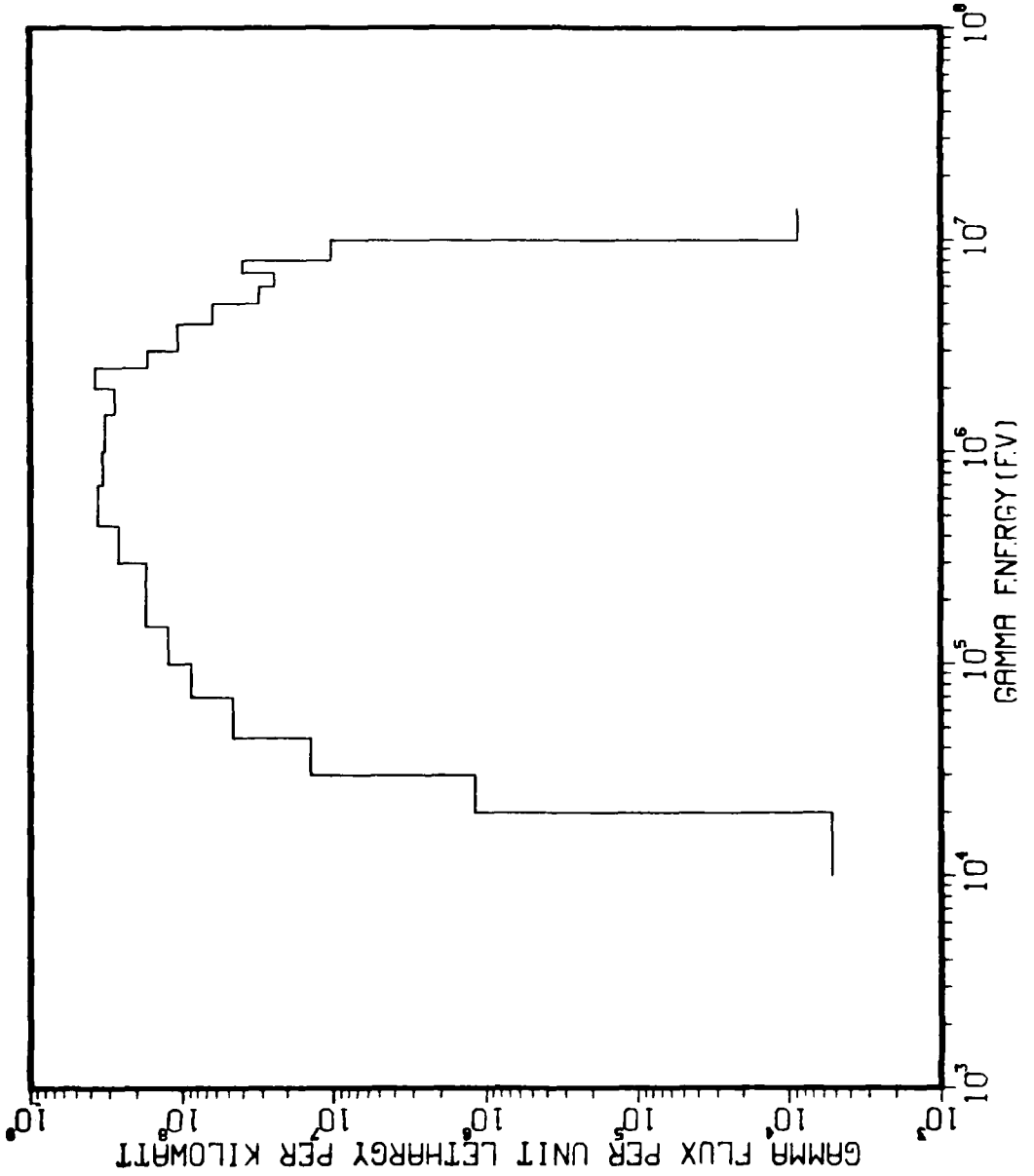

Figure II.6.54. Total (Back+Front) Gamma Flux vs Energy Free Field ER2 100 cms from Reactor.

Table II.6.18. Neutron Flux per Unit Lethargy per Kilowatt.

ER2 FREE FIELD 100 CMS FROM REACTOR

GROUP	ENERGY (EV)	FRONT	BACK	TOTAL
1	1.960E+07	4.68E+03	0.00E+00	4.68E+03
2	1.690E+07	2.50E+04	0.00E+00	2.50E+04
3	1.490E+07	6.15E+04	0.00E+00	6.15E+04
4	1.420E+07	7.41E+04	0.00E+00	7.41E+04
5	1.380E+07	1.62E+05	0.00E+00	1.62E+05
6	1.280E+07	2.25E+05	0.00E+00	2.25E+05
7	1.220E+07	4.59E+05	0.00E+00	4.59E+05
8	1.110E+07	8.88E+05	0.00E+00	8.88E+05
9	1.000E+07	1.73E+06	0.00E+00	1.73E+06
10	9.050E+06	2.84E+06	0.00E+00	2.84E+06
11	8.190E+06	4.53E+06	0.00E+00	4.53E+06
12	7.410E+06	7.49E+06	1.06E+02	7.49E+06
13	6.380E+06	1.36E+07	1.47E+03	1.36E+07
14	4.970E+06	1.72E+07	9.53E+03	1.73E+07
15	4.720E+06	2.01E+07	2.47E+04	2.01E+07
16	4.070E+06	2.32E+07	9.54E+04	2.33E+07
17	3.010E+06	3.17E+07	4.73E+05	3.21E+07
18	2.390E+06	3.60E+07	4.17E+05	3.64E+07
19	2.310E+06	2.80E+07	4.04E+05	2.84E+07
20	1.830E+06	2.38E+07	4.08E+05	2.43E+07
21	1.110E+06	1.68E+07	4.80E+05	1.73E+07
22	5.500E+05	8.19E+06	3.48E+05	8.54E+06
23	1.580E+05	5.89E+06	3.00E+05	6.19E+06
24	1.110E+05	4.55E+06	2.55E+05	4.81E+06
25	5.250E+04	3.54E+06	2.33E+05	3.77E+06
26	2.480E+04	3.80E+06	2.29E+05	4.02E+06
27	2.190E+04	3.49E+06	2.31E+05	3.72E+06
28	1.030E+04	3.23E+06	2.42E+05	3.47E+06
29	3.350E+03	3.14E+06	2.55E+05	3.39E+06
30	1.230E+03	3.13E+06	2.69E+05	3.40E+06
31	5.830E+02	3.10E+06	2.88E+05	3.39E+06
32	1.010E+02	3.11E+06	3.06E+05	3.42E+06
33	2.900E+01	3.12E+06	3.18E+05	3.43E+06
34	1.070E+01	3.09E+06	3.28E+05	3.42E+06
35	3.060E+00	3.09E+06	3.37E+05	3.43E+06
36	1.130E+00	3.04E+06	3.42E+05	3.38E+06
37	4.140E-01	2.79E+06	1.59E+05	2.95E+06

Table II.6.19. Gamma Flux per Unit Lethargy per Kilowatt.

ER2 FREE FIELD 100 CMS FROM REACTOR

GROUP	ENERGY (EV)	FRONT	BACK	TOTAL
1	1.400E+07	6.62E+03	2.17E+03	8.79E+03
2	1.000E+07	1.03E+07	0.00E+00	1.03E+07
3	8.900E+06	3.98E+07	0.00E+00	3.98E+07
4	7.000E+06	2.44E+07	1.19E+05	2.45E+07
5	6.000E+06	3.08E+07	1.08E+05	3.09E+07
6	5.000E+06	6.26E+07	5.84E+03	6.26E+07
7	4.000E+06	1.06E+08	0.00E+00	1.06E+08
8	3.000E+06	1.69E+08	0.00E+00	1.69E+08
9	2.500E+06	3.68E+08	2.78E+06	3.71E+08
10	2.000E+06	2.74E+08	0.00E+00	2.74E+08
11	1.500E+06	3.18E+08	0.00E+00	3.18E+08
12	1.000E+06	3.33E+08	5.38E+05	3.33E+08
13	7.000E+05	3.55E+08	1.22E+06	3.57E+08
14	4.500E+05	2.60E+08	5.42E+05	2.61E+08
15	3.000E+05	1.55E+08	1.76E+07	1.72E+08
16	1.500E+05	1.03E+08	2.13E+07	1.24E+08
17	1.000E+05	6.48E+07	2.24E+07	8.72E+07
18	7.000E+04	2.91E+07	1.76E+07	4.66E+07
19	4.500E+04	7.41E+06	6.82E+06	1.42E+07
20	3.000E+04	5.93E+05	5.98E+05	1.19E+06
21	2.000E+04	2.68E+03	2.52E+03	5.20E+03

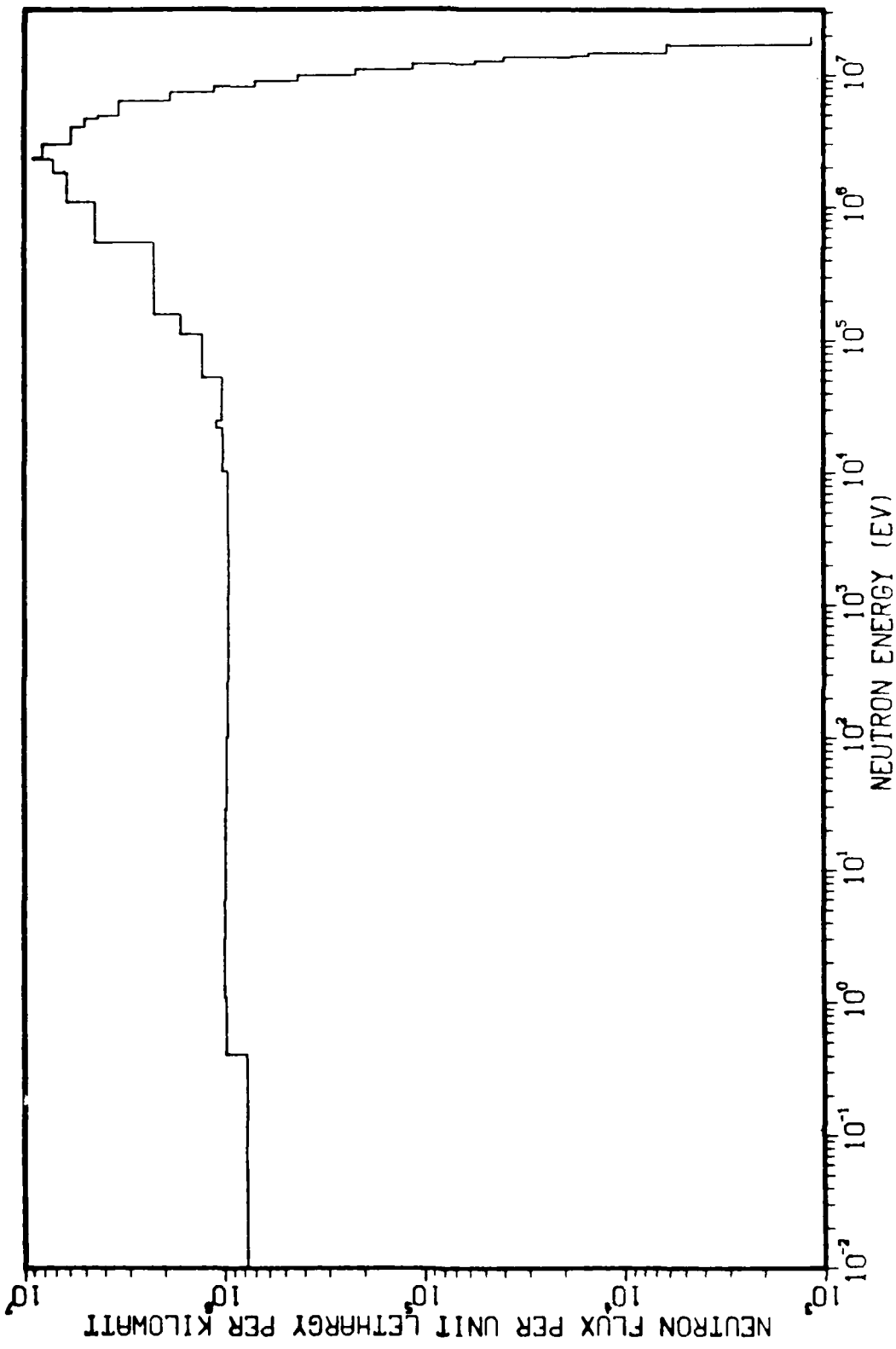

Figure II.6.55. Front (1-D) Neutron Flux vs Energy Free Field ER2 200 cms from Reactor.

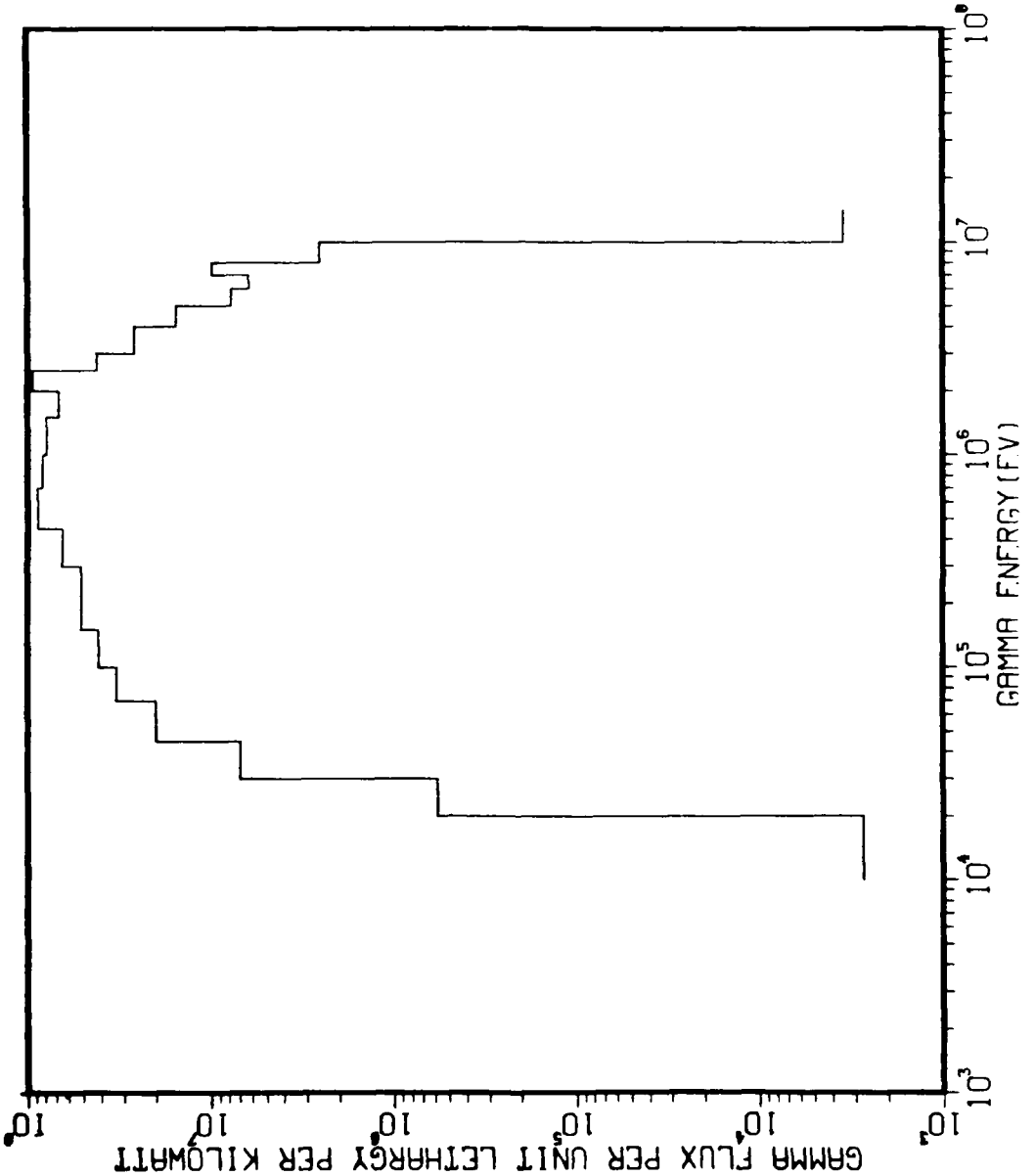

Figure II.6.56. Front Gamma Flux vs Energy Free Field ER2 200 cms from Reactor.

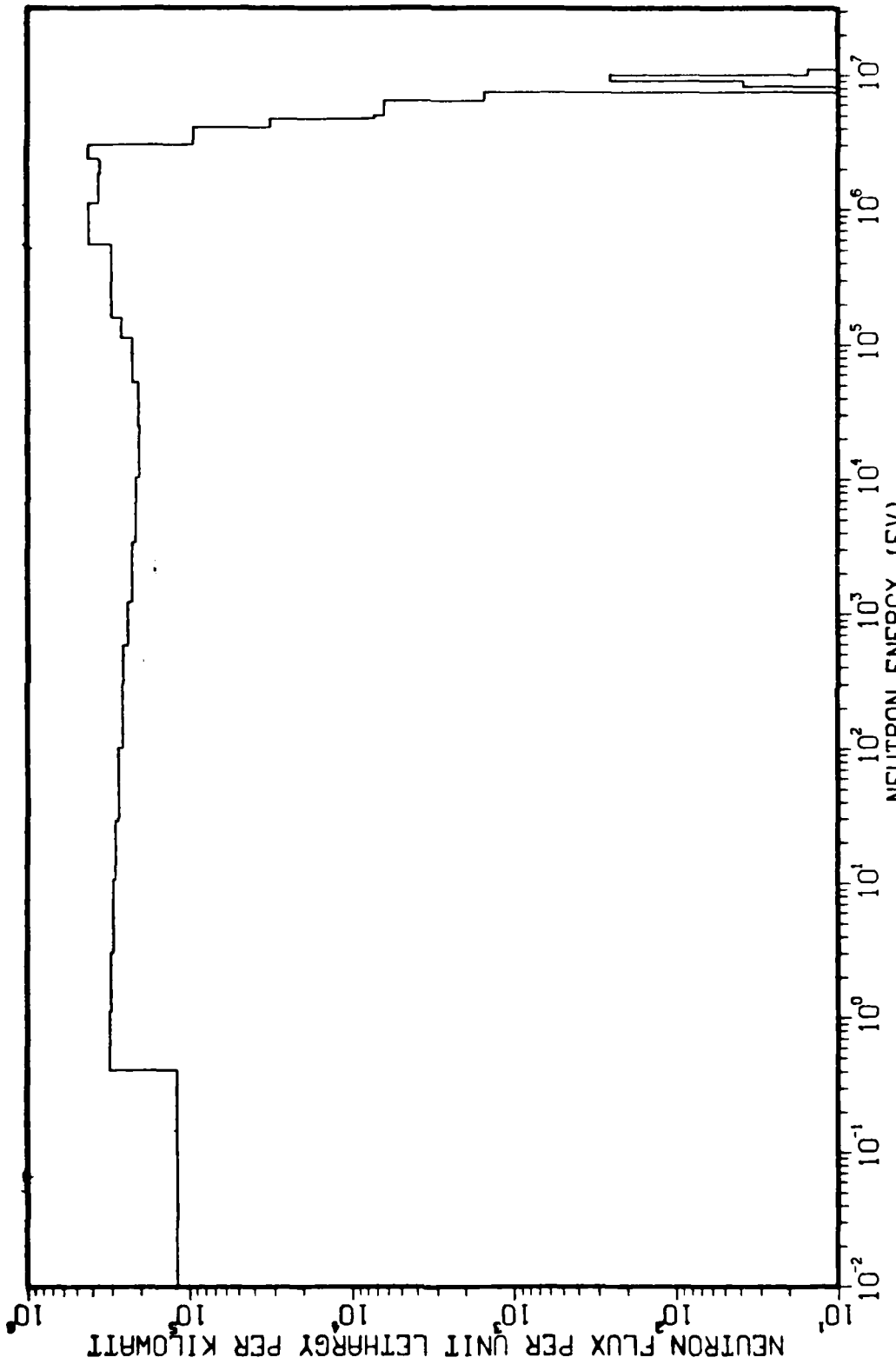

Figure II.6.57. Back (1-D) Neutron Flux vs Energy Free Field ER2 200 cms from Reactor.

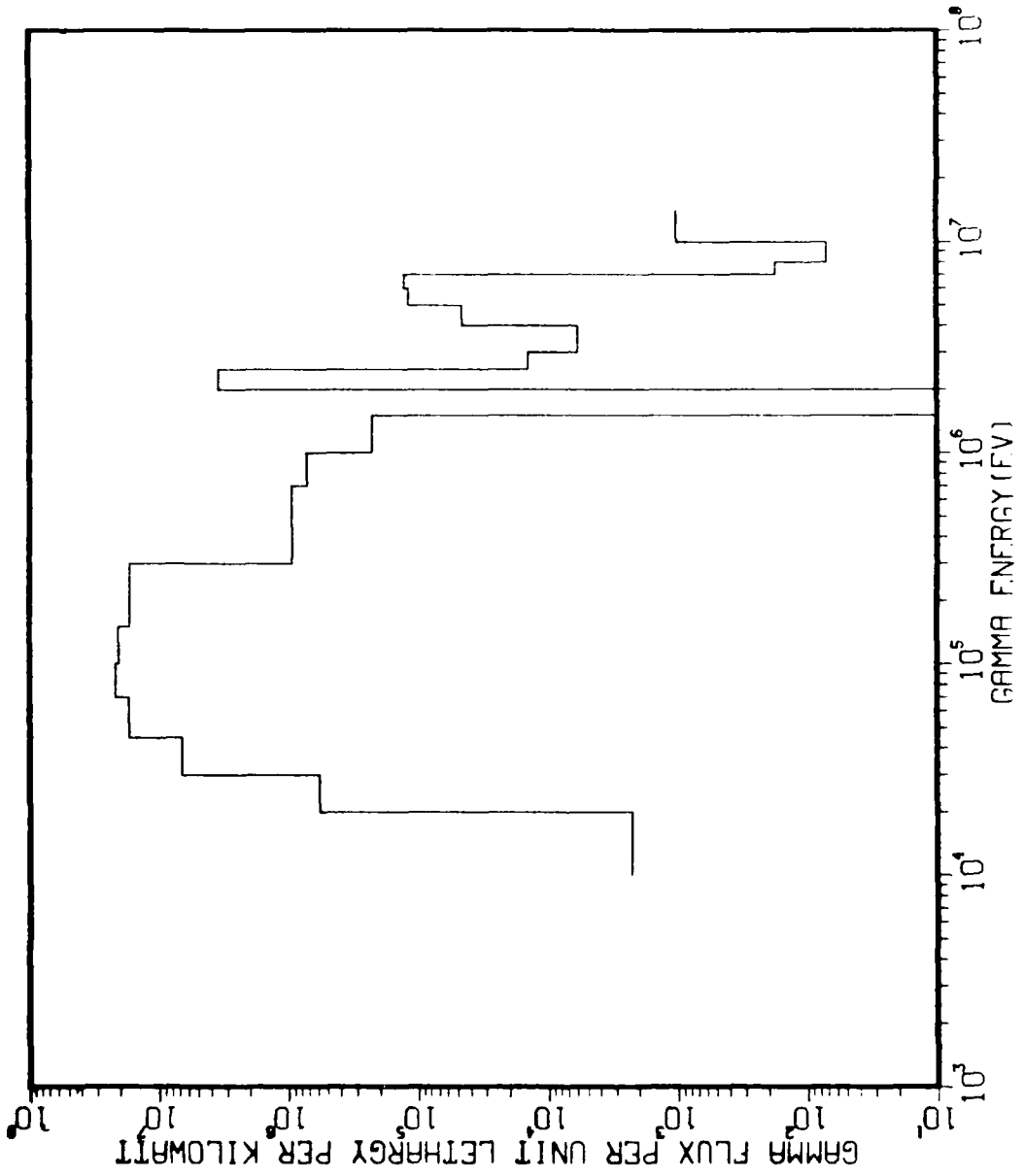

Figure II.6.58. Back Gamma Flux vs Energy Free Field ER2 200 cms from Reactor.

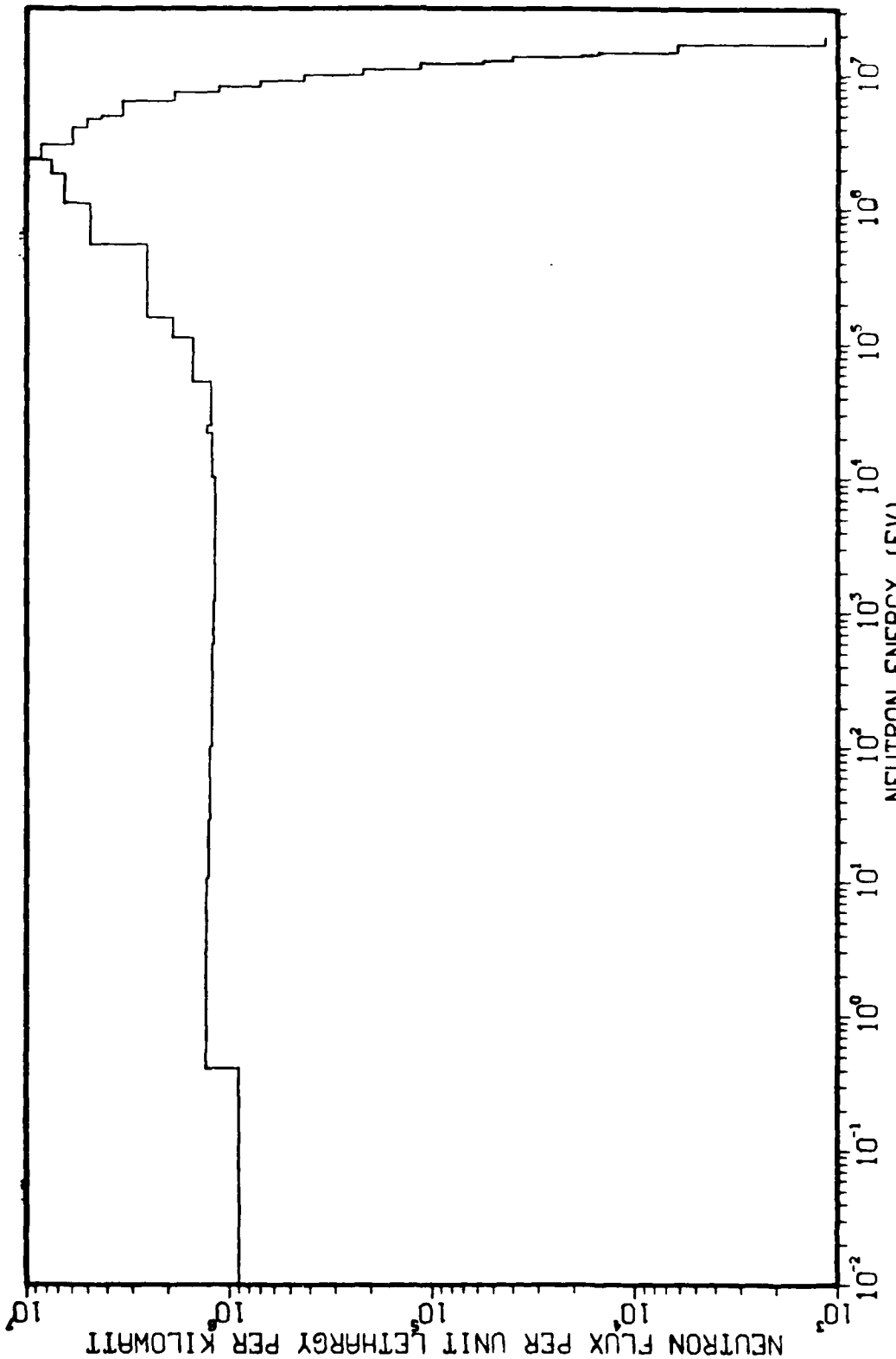

Figure II.6.59. Total (Frcnt+Back, 1-D) Neutron Flux vs Energy Free Field ER2 200 cms from Reactor.

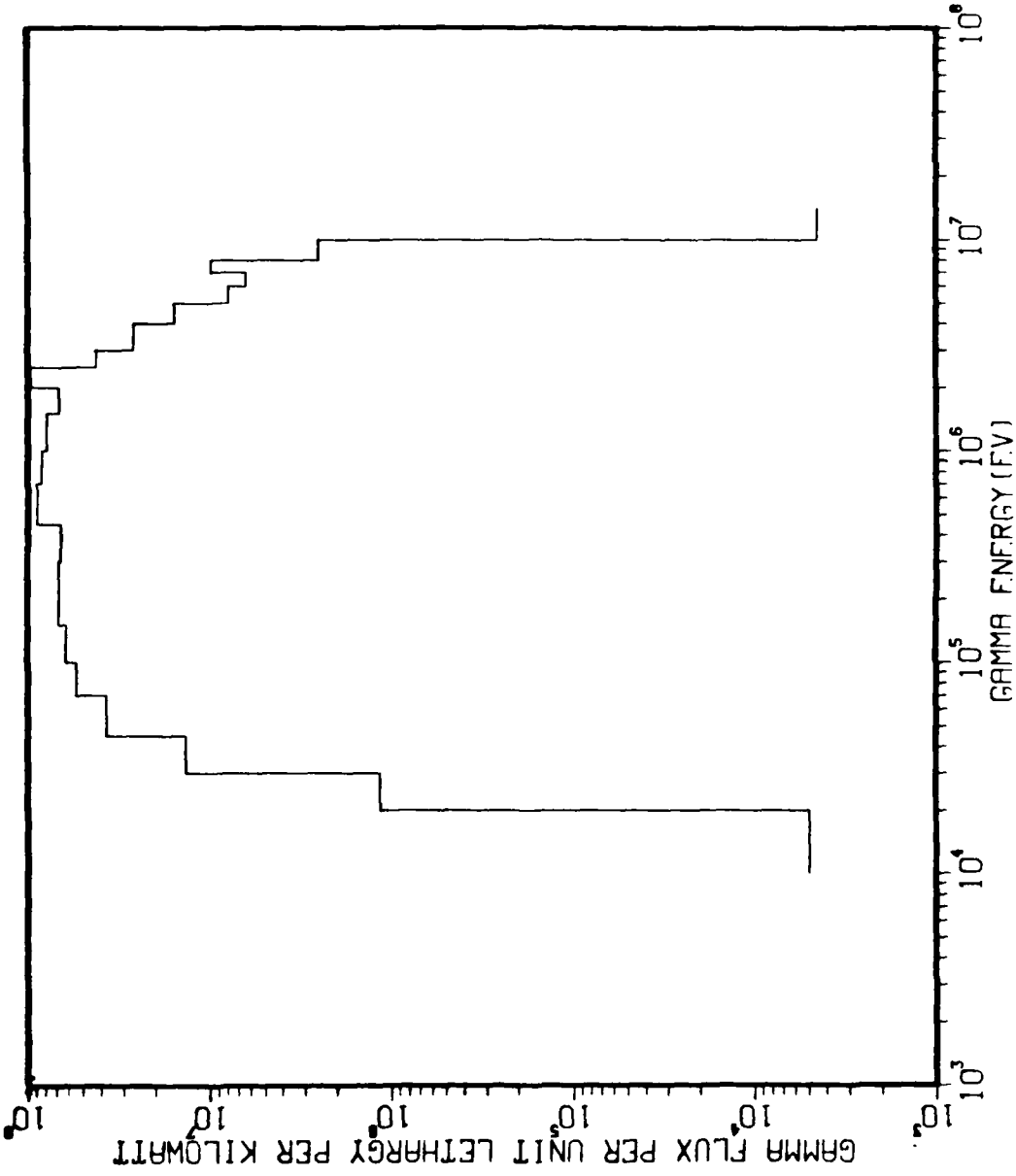

Figure II.6.60. Total (Front+Back) Gamma Flux vs Energy Free Field ER2 200 cms from Reactor.

Table II.6.20. Neutron Flux per Unit Lethargy per Kilowatt.

ER2 FREE FIELD 200 CMS FROM REACTOR

GROUP	ENERGY (EV)	FRONT	BACK	TOTAL
1	1.960E+07	1.16E+03	0.00E+00	1.16E+03
2	1.690E+07	6.16E+03	0.00E+00	6.16E+03
3	1.490E+07	1.52E+04	0.00E+00	1.52E+04
4	1.420E+07	1.83E+04	0.00E+00	1.83E+04
5	1.380E+07	4.00E+04	0.00E+00	4.00E+04
6	1.280E+07	5.55E+04	0.00E+00	5.55E+04
7	1.220E+07	1.13E+05	0.00E+00	1.13E+05
8	1.110E+07	2.19E+05	1.54E+01	2.19E+05
9	1.000E+07	4.26E+05	2.56E+02	4.27E+05
10	9.050E+06	7.01E+05	3.84E+01	7.01E+05
11	8.190E+06	1.12E+06	0.00E+00	1.12E+06
12	7.410E+06	1.85E+06	1.54E+03	1.85E+06
13	6.380E+06	8.35E+06	6.32E+03	8.36E+06
14	4.970E+06	4.27E+06	7.34E+03	4.27E+06
15	4.720E+06	4.98E+06	8.18E+04	5.01E+06
16	4.070E+06	5.81E+06	9.44E+04	5.90E+06
17	3.010E+06	8.11E+06	4.16E+05	8.53E+06
18	2.390E+06	9.11E+06	3.57E+05	9.46E+06
19	2.310E+06	7.16E+06	3.53E+05	7.52E+06
20	1.830E+06	6.12E+06	3.57E+05	6.48E+06
21	1.110E+06	4.42E+06	4.17E+05	4.84E+06
22	5.500E+05	2.24E+06	3.03E+05	2.55E+06
23	1.580E+05	1.65E+06	2.60E+05	1.91E+06
24	1.110E+05	1.29E+06	2.24E+05	1.51E+06
25	5.250E+04	1.02E+06	2.06E+05	1.23E+06
26	2.480E+04	1.09E+06	2.03E+05	1.30E+06
27	2.190E+04	1.02E+06	2.03E+05	1.22E+06
28	1.030E+04	9.63E+05	2.14E+05	1.18E+06
29	3.350E+03	9.50E+05	2.26E+05	1.18E+06
30	1.230E+03	9.58E+05	2.39E+05	1.20E+06
31	5.830E+02	9.64E+05	2.57E+05	1.22E+06
32	1.010E+02	9.79E+05	2.74E+05	1.25E+06
33	2.900E+01	9.89E+05	2.86E+05	1.28E+06
34	1.070E+01	9.91E+05	2.96E+05	1.29E+06
35	3.060E+00	9.96E+05	3.05E+05	1.30E+06
36	1.130E+00	9.87E+05	3.11E+05	1.30E+06
37	4.140E-01	7.76E+05	1.19E+05	8.96E+05

Table II.6.21. Gamma Flux per Unit Lethargy per Kilowatt.

ER2 FREE FIELD 200 CMS FROM REACTOR

GROUP	ENERGY (EV)	FRONT	BACK	TOTAL
1	1.400E+07	3.47E+03	1.02E+03	4.49E+03
2	1.000E+07	2.54E+06	7.08E+01	2.54E+06
3	8.000E+06	9.80E+06	1.75E+02	9.81E+06
4	7.000E+06	6.15E+06	1.27E+05	6.28E+06
5	6.000E+06	7.74E+06	1.18E+05	7.85E+06
6	5.000E+06	1.55E+07	4.60E+04	1.55E+07
7	4.000E+06	2.62E+07	5.89E+03	2.62E+07
8	3.000E+06	4.17E+07	1.42E+04	4.18E+07
9	2.500E+06	9.33E+07	3.46E+06	9.68E+07
10	2.000E+06	6.77E+07	0.00E+00	6.77E+07
11	1.500E+06	7.88E+07	2.26E+05	7.90E+07
12	1.000E+06	8.26E+07	7.15E+05	8.33E+07
13	7.000E+05	8.83E+07	9.49E+05	8.93E+07
14	4.500E+05	6.49E+07	9.38E+05	6.58E+07
15	3.000E+05	5.09E+07	1.68E+07	6.77E+07
16	1.500E+05	4.11E+07	2.05E+07	6.17E+07
17	1.000E+05	3.26E+07	2.18E+07	5.45E+07
18	7.000E+04	2.00E+07	1.72E+07	3.72E+07
19	4.500E+04	6.89E+06	6.71E+06	1.36E+07
20	3.000E+04	5.80E+05	5.79E+05	1.16E+06
21	2.000E+04	2.70E+03	2.29E+03	5.00E+03

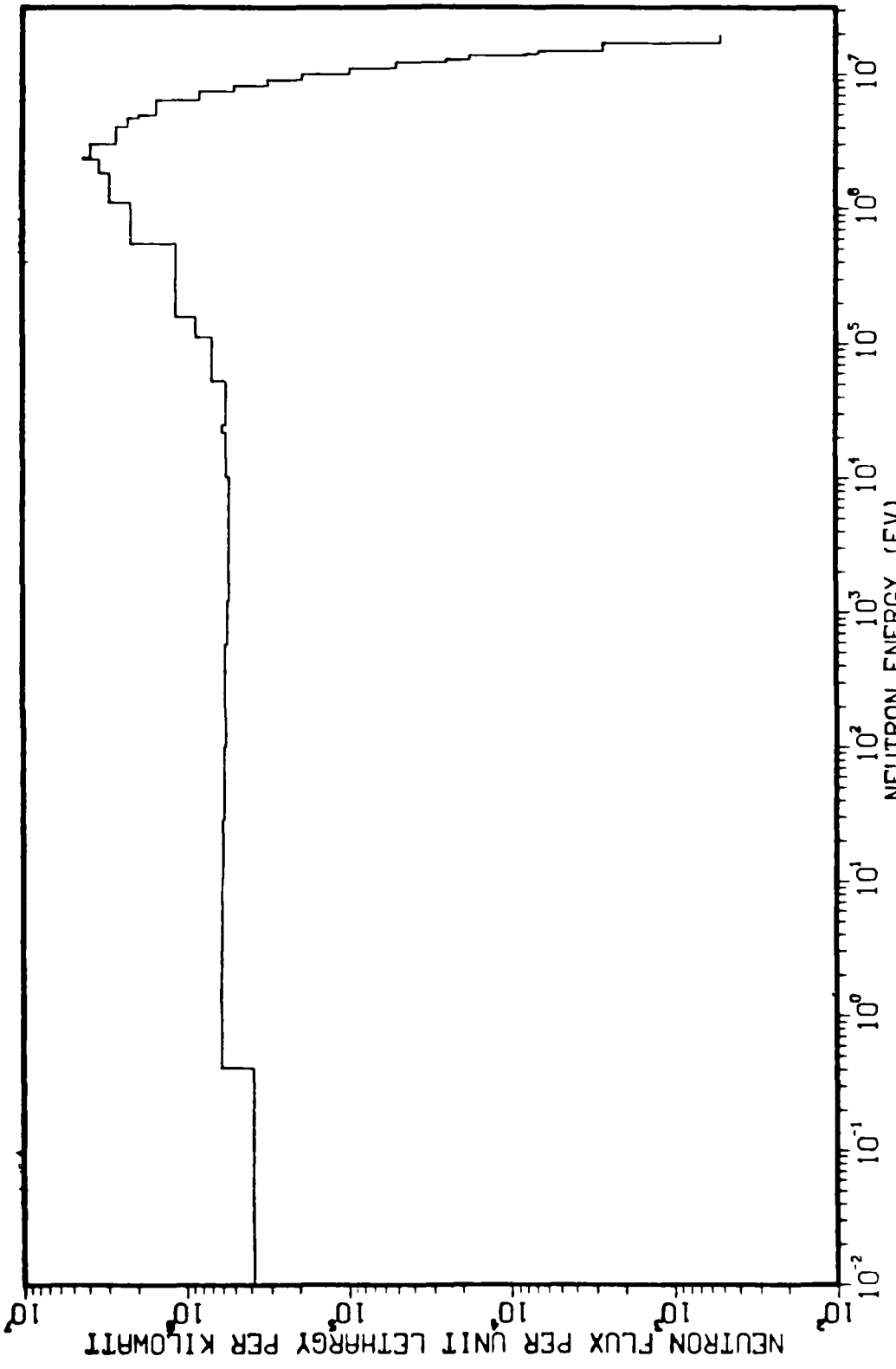

Figure II.6.61. Front (1-D) Neutron Flux vs Energy Free Field ER2 300 cms from Reactor.

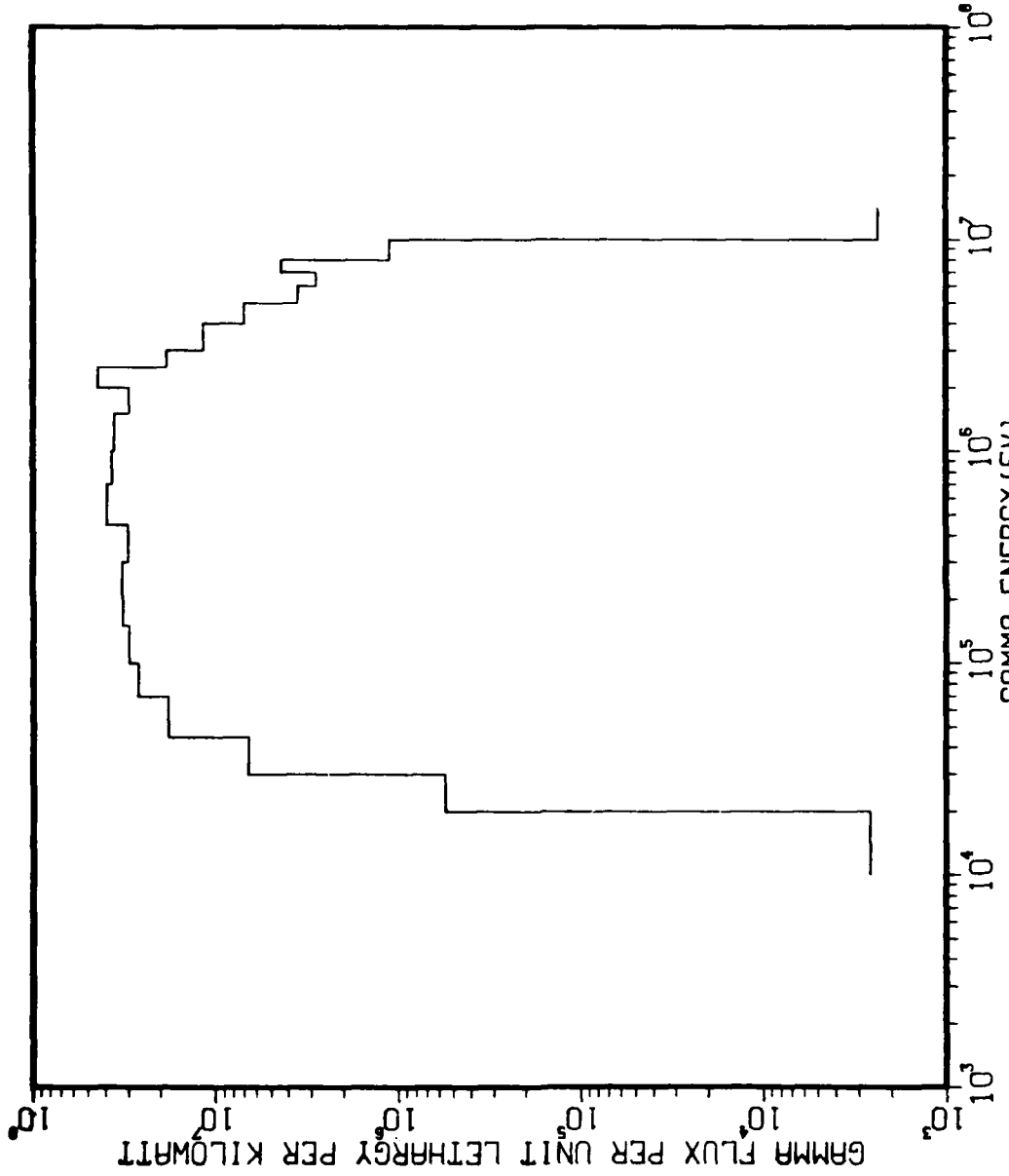

Figure II.6.62. Front Gamma Flux vs Energy Free Field ER2 300 cms from Reactor.

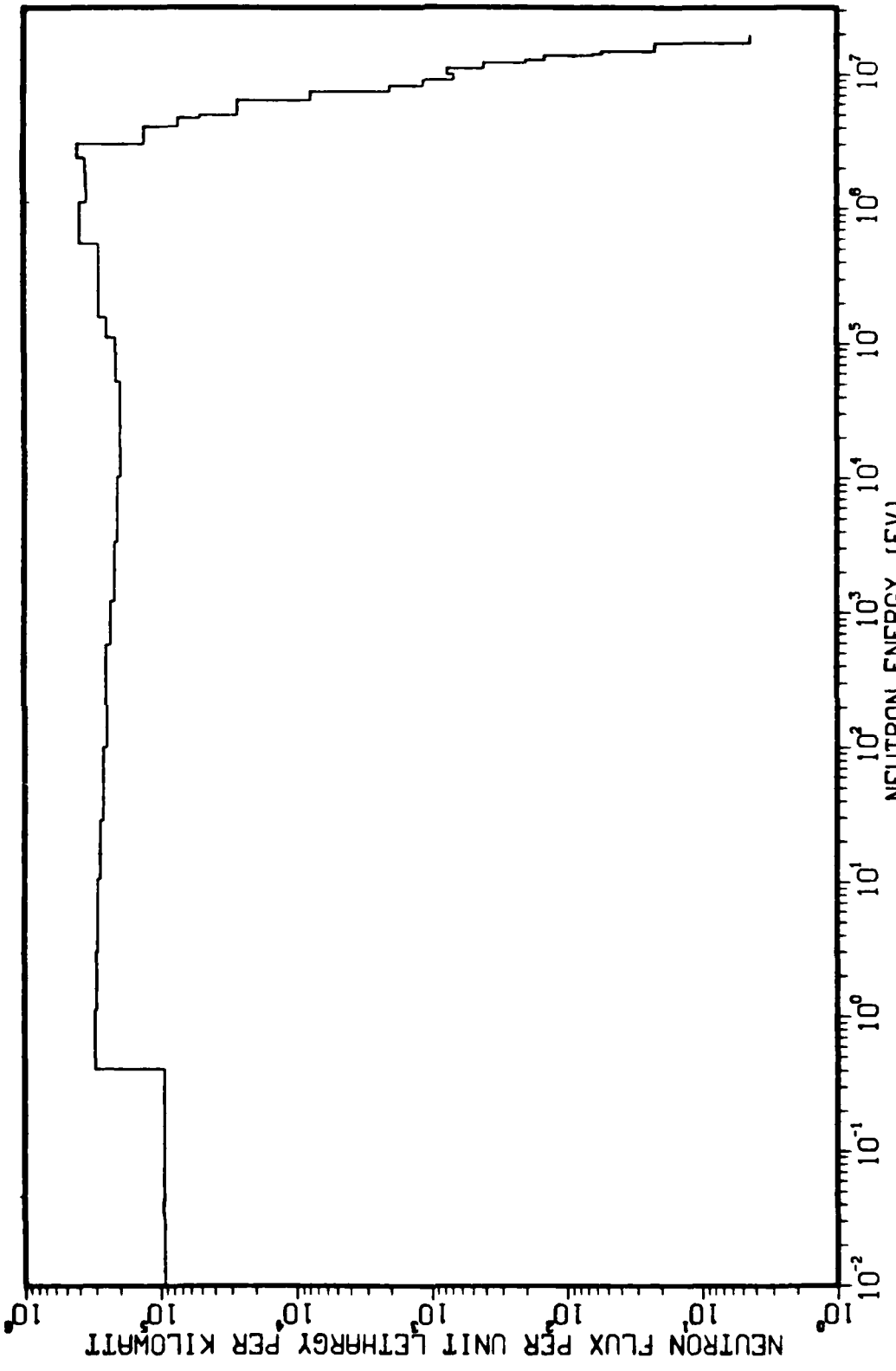

Figure II.6.63. Back (1-D) Neutron Flux vs Energy Free Field ER2 300 cms from Reactor.

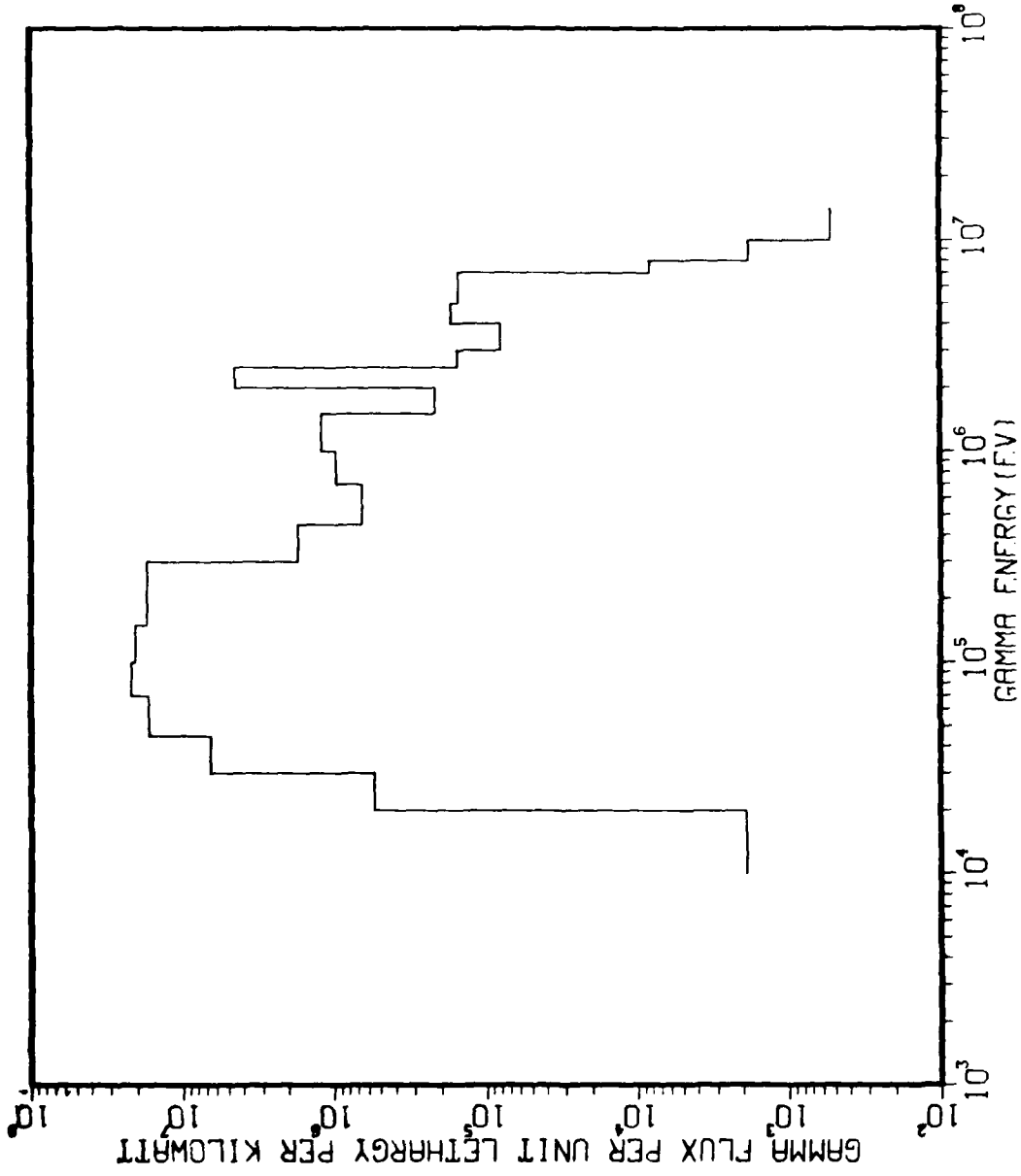

Figure II.6.64. Back Gamma Flux vs Energy Free Field ER2 300 cms from Reactor.

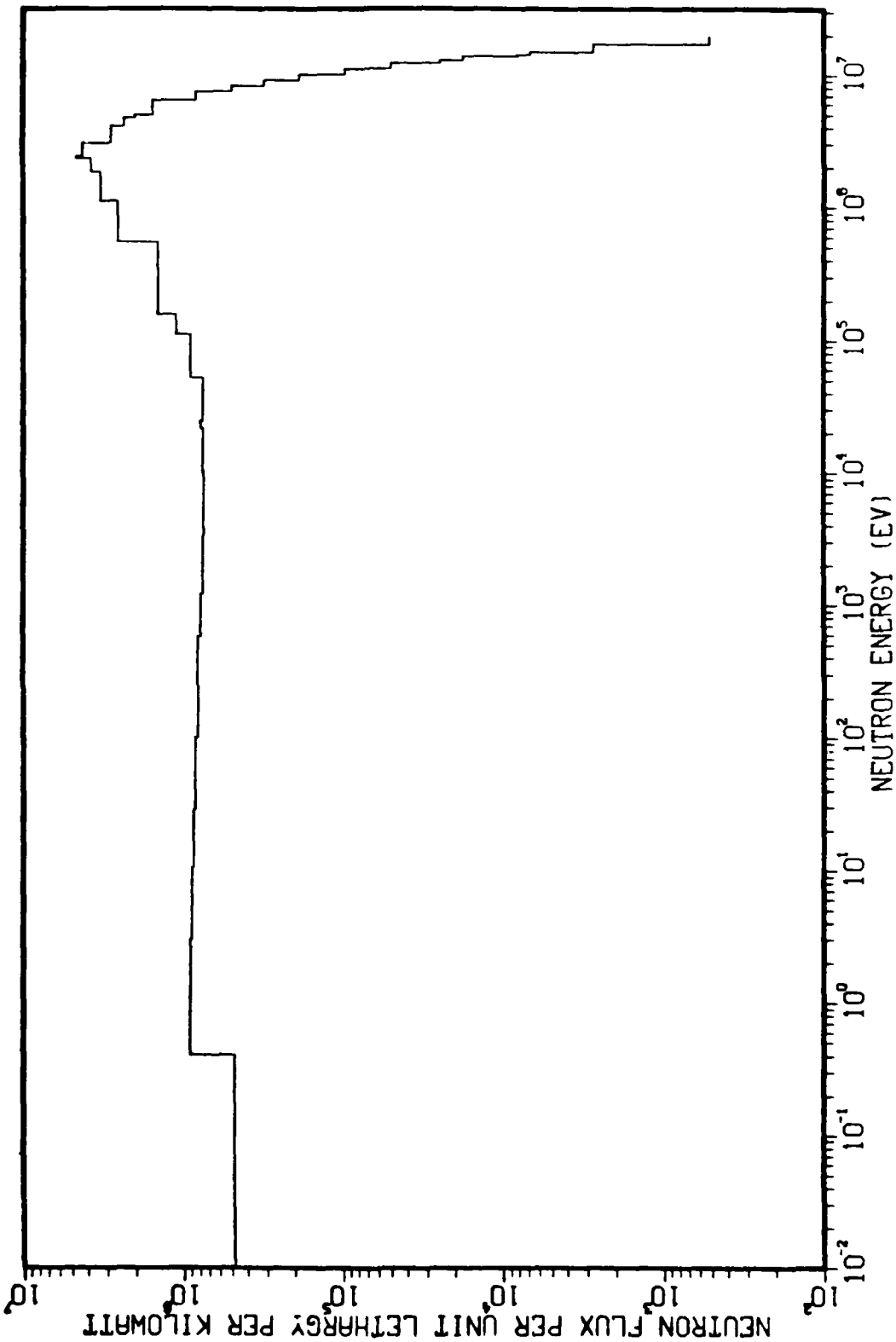

Figure II.6.65. Total (Front+Back, 1-D) Neutron Flux vs Energy Free Field ER2
300 cms from Reactor.

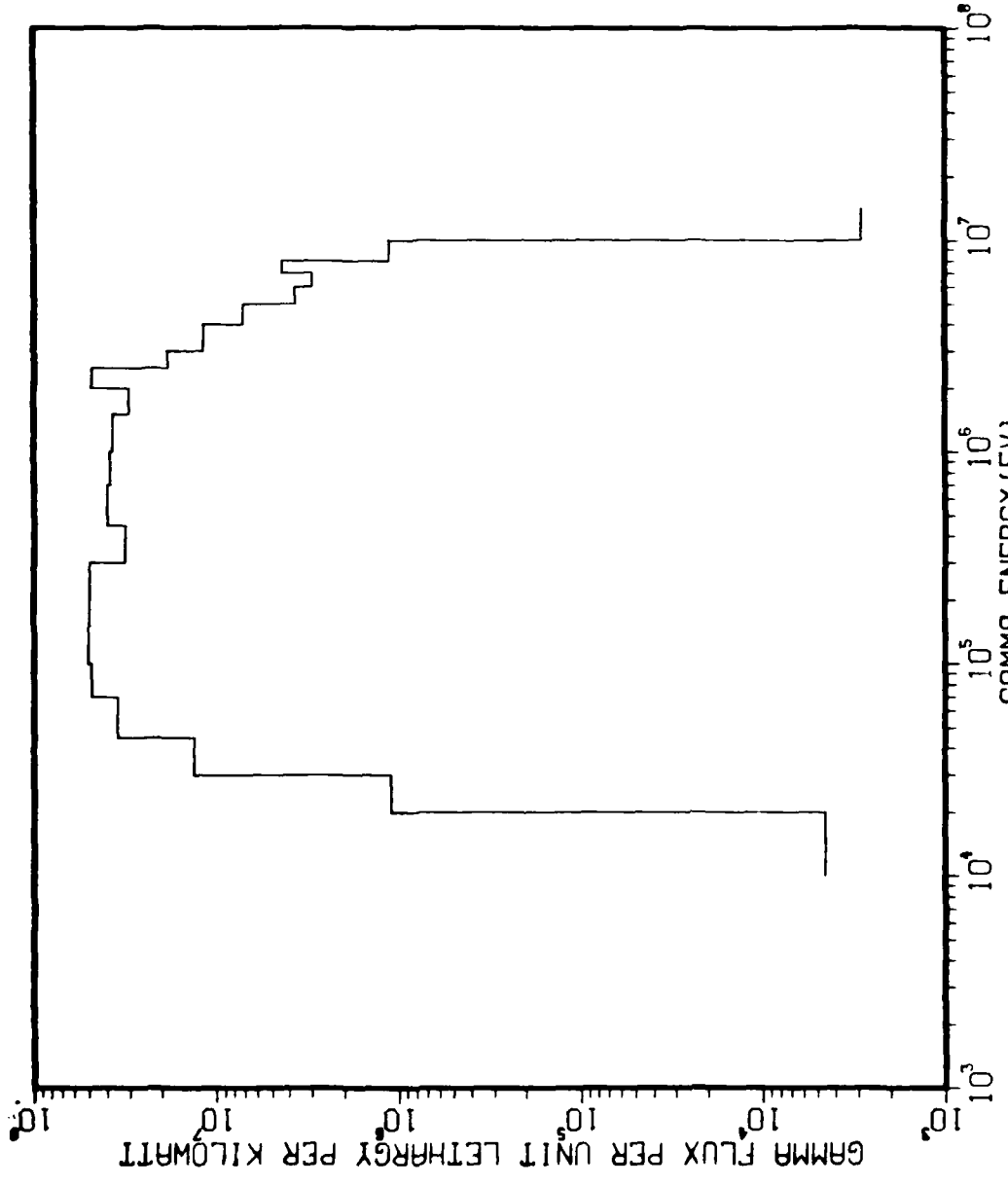

Figure II.6.66. Total (Front+Back) Gamma Flux vs Energy Free Field ER2 300 cms from Reactor.

Table II.6.22. Neutron Flux per Unit Lethargy per Kilowatt.

ER2 FREE FIELD 900 CMS FROM REACTOR

GROUP	ENERGY (EV)	FRONT	BACK	TOTAL
1	1.960E+07	5.12E+02	4.38E+00	5.16E+02
2	1.690E+07	2.73E+03	2.21E+01	2.75E+03
3	1.490E+07	6.71E+03	5.48E+01	6.77E+03
4	1.420E+07	8.08E+03	6.33E+01	8.15E+03
5	1.380E+07	1.77E+04	1.45E+02	1.79E+04
6	1.280E+07	2.46E+04	1.99E+02	2.48E+04
7	1.220E+07	5.02E+04	4.07E+02	5.06E+04
8	1.110E+07	9.72E+04	7.63E+02	9.79E+04
9	1.000E+07	1.89E+05	6.77E+02	1.90E+05
10	9.050E+06	3.11E+05	1.14E+03	3.12E+05
11	8.190E+06	4.96E+05	2.02E+03	4.98E+05
12	7.410E+06	8.26E+05	7.69E+03	8.34E+05
13	6.380E+06	1.51E+06	2.66E+04	1.54E+06
14	4.970E+06	1.94E+06	4.98E+04	1.99E+06
15	4.720E+06	2.26E+06	7.26E+04	2.33E+06
16	4.070E+06	2.66E+06	1.29E+05	2.79E+06
17	3.010E+06	3.82E+06	4.06E+05	4.23E+06
18	2.390E+06	4.24E+06	3.55E+05	4.59E+06
19	2.310E+06	3.38E+06	3.51E+05	3.73E+06
20	1.830E+06	2.91E+06	3.50E+05	3.26E+06
21	1.110E+06	2.17E+06	3.90E+05	2.56E+06
22	5.500E+05	1.15E+06	2.83E+05	1.43E+06
23	1.580E+05	8.65E+05	2.46E+05	1.11E+06
24	1.110E+05	6.88E+05	2.13E+05	9.01E+05
25	5.250E+04	5.62E+05	1.97E+05	7.59E+05
26	2.480E+04	5.90E+05	1.95E+05	7.86E+05
27	2.190E+04	5.60E+05	1.96E+05	7.55E+05
28	1.030E+04	5.41E+05	2.06E+05	7.47E+05
29	3.350E+03	5.42E+05	2.19E+05	7.60E+05
30	1.230E+03	5.52E+05	2.31E+05	7.84E+05
31	5.830E+02	5.65E+05	2.49E+05	8.14E+05
32	1.010E+02	5.81E+05	2.66E+05	8.47E+05
33	2.900E+01	5.92E+05	2.78E+05	8.71E+05
34	1.070E+01	5.99E+05	2.89E+05	8.88E+05
35	3.060E+00	6.06E+05	2.98E+05	9.04E+05
36	1.180E+00	6.05E+05	3.04E+05	9.09E+05
37	4.140E-01	3.86E+05	9.48E+04	4.81E+05

Table II.6.23. Gamma Flux per Unit Lethargy per Kilowatt.

ER2 FREE FIELD 800 CMS FROM REACTOR

GROUP	ENERGY (EV)	FRONT	BACK	TOTAL
1	1.400E+07	2.35E+03	5.21E+02	2.87E+03
2	1.000E+07	1.12E+06	1.82E+03	1.13E+06
3	8.000E+06	4.35E+06	8.29E+03	4.35E+06
4	7.000E+06	2.82E+06	1.52E+05	2.98E+06
5	6.000E+06	3.53E+06	1.51E+05	3.68E+06
6	5.000E+06	7.01E+06	1.70E+05	7.18E+06
7	4.000E+06	1.16E+07	8.01E+04	1.17E+07
8	3.000E+06	1.85E+07	1.54E+05	1.87E+07
9	2.500E+06	4.42E+07	4.49E+06	4.87E+07
10	2.000E+06	3.00E+07	2.17E+05	3.02E+07
11	1.500E+06	3.59E+07	1.20E+06	3.71E+07
12	1.000E+06	3.72E+07	9.68E+05	3.82E+07
13	7.000E+05	3.94E+07	6.63E+05	4.01E+07
14	4.500E+05	3.02E+07	1.73E+06	3.20E+07
15	3.000E+05	3.25E+07	1.72E+07	4.97E+07
16	1.500E+05	2.98E+07	2.06E+07	5.04E+07
17	1.000E+05	2.66E+07	2.17E+07	4.83E+07
18	7.000E+04	1.82E+07	1.68E+07	3.50E+07
19	4.500E+04	6.68E+06	6.58E+06	1.33E+07
20	3.000E+04	5.56E+05	5.49E+05	1.11E+06
21	2.000E+04	2.60E+03	1.92E+03	4.53E+03

Table II.6.24. Front Response as a Function of Distance in ER2.

Response	Distance from Reactor in ER2 (cms) 50	100	200	300
Sulfur Activation (acts/cc-s/atom/bn·cm/kW)	2.15+7	5.16+6	1.29+6	5.88+5
Silicon Damage (1 MeV Equivalent n/cm^2-s/kW)	3.53+8	8.44+7	2.18+7	1.04+7
Neutron Dose (rads/s/kW)	1.20+0	2.87-1	7.52-2	3.65-2
Gamma Dose (rad/s/kW)	1.88+0	4.51-1	1.14-1	5.32-2
Neutron Dose (rem/s/kW)	9.65+0	2.31+0	5.96-1	2.85-1
Total Dose (rad/s/kW)	3.08+0	7.38-1	1.89-1	8.97-2
Total Dose (rem/s/kW)	1.15+1	2.76+0	7.10-1	3.38-1
Total Neutron Flux (n/cm^2-s/kW)	6.03+8	1.44+8	4.00+7	2.06+7
Neutron Flux >1 MeV (n/cm^2-s/kW)	1.91+8	4.58+7	1.16+7	5.43+6

Table II.6.25. Back Response as a Function of Distance in ER2.

Response	Distance from Reactor in ER2 (cms)			
	50	100	200	300
Sulfur Activation (acts/cc-s/atom/bn·cm/kW)	3.17+4	2.18+4	2.06+4	2.67+4
Silicon Damage (1 MeV Equivalent n/cm^2-s/kW)	2.11+6	1.63+6	1.42+6	1.38+6
Neutron Dose (rads/s/kW)	8.99-3	6.95-3	5.98-3	5.73-3
Gamma Dose (rad/s/kW)	3.82-3	3.59-3	3.72-3	4.38-3
Neutron Dose (rem/s/kW)	5.51-2	4.29-2	3.75-2	3.67-2
Total Dose (rad/s/kW)	1.28-2	1.05-2	9.70-3	1.01-2
Total Dose (rem/s/kW)	5.89-2	4.64-2	4.12-2	4.11-2
Total Neutron Flux (n/cm^2-s/kW)	9.01+6	6.99+6	5.92+6	5.47+6
Neutron Flux >1 MeV (n/cm^2-s/kW)	6.91+5	5.22+5	4.63+5	4.78+5

Table II.6.26. Total Response as a Function of Distance in ER2.

Response	Distance from Reactor in ER2 (cms) 50	100	200	300
Sulfur Activation (acts/cc-s/atom/bn·cm/kW)	2.16+7	5.18+6	1.31+6	6.15+5
Silicon Damage (1 MeV Equivalent n/cm^2-s/kW)	3.55+8	8.60+7	2.33+7	1.18+7
Neutron Dose (rads/s/kW)	1.21+0	2.94-1	8.12-2	4.22-2
Gamma Dose (rad/s/kW)	1.88+0	4.54-1	1.18-1	5.76-2
Neutron Dose (rem/s/kW)	9.71+0	2.35+0	6.34-1	3.21-1
Total Dose (rad/s/kW)	3.09+0	7.49-1	1.99-1	9.98-2
Total Dose (rem/s/kW)	1.16+1	2.81+0	7.51-1	3.79-1
Total Neutron Flux (n/cm^2-s/kW)	6.12+8	1.51+8	4.60+7	2.61+7
Neutron Flux >1 MeV (n/cm^2-s/kW)	1.92+8	4.63+7	1.21+7	5.91+6

7. CONCLUSIONS AND SUMMARY

One-dimensional and three-dimensional calculations have been done for various reactor/exposure room cofigurations at the AFRRI Triga reactor facility. In addition to supplying input spectra for the unfolding of the foil data, the calculations were extended to other arrangements that could be of use for future experiments. It was found that except in extreme cases involving complex shapes of hydrogenous materials, one-dimensional techniques were adequate to characterize the neutron and gamma-ray fields in and around the reactor. In addition to spectra and integral results, the calculations also yielded information on the angular distribution of the radiation, especially useful for future irradiation experiments involving large thick subjects.

The excellent agreement between the calculations and the measurements in spectral shape as well as intensity, validated the calculational procedures and allowed the extension of calculations to configurations for which there was no experimental data.

The calculated spectra have been tabulated in such a way as to be of maximum use to the AFRRI Triga user and as input for further calculations such as cell kill, radiation effects, or further radiation transport analysis. The overall analytic approach taken in performing these calculations also leaves itself open to efficient continuation due to the coupled nature of the runs which prevents unnecessary repetition of calculation in certain sections of the problem.

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